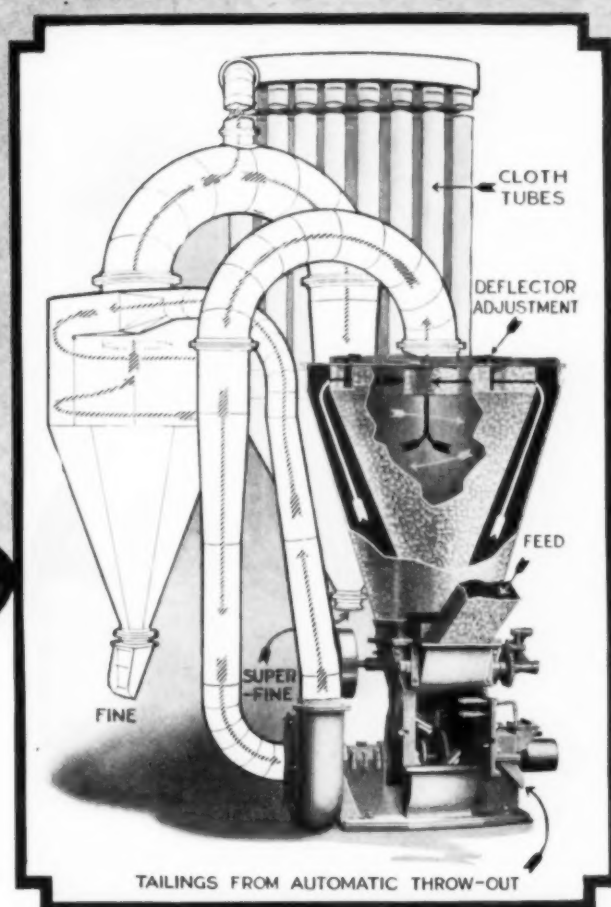


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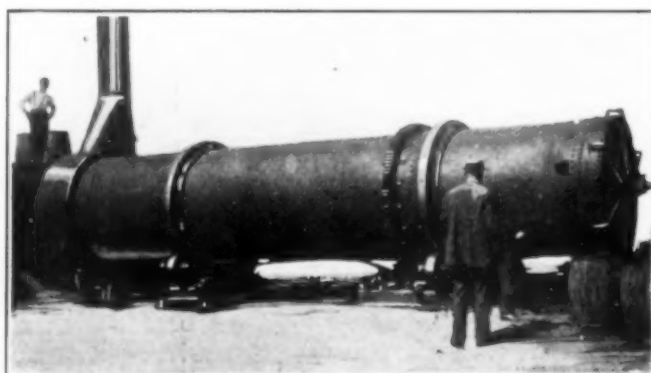
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Dividing the Sheep From The Goats in Research

MOST interesting men have opinions, and if we look for them we can find them. In reading over lately a number of scholarly addresses on research by Dr. JOHN J. CARTY, vice president of the American Telephone & Telegraph Co., we find a clearly marked conviction that is indicated in all of them and which opens up an interesting and almost endless subject for debate. It is doubtful if in this or any other country there is so large a sum expended annually for industrial research under the supervision of any one man as is done under the supervision of Colonel CARTY. He is familiar with the haunts of discovery as well as with a great number of problems of applied physics, chemistry and mechanics, and he has participated in the solution of many of them.

In all these writings we find the line drawn between research in pure and in applied science. Pure science, to his mind, is properly the subject for research in universities—which includes colleges of technology—whereas research in applied science belongs within the scope of study of industrial and commercial laboratories, institutions and consultants. This is a general statement of his attitude which includes the frank admission of exceptions. It is not an infallible rule. It is a rather a general principle designed to serve as an aid to progress, while experience and common sense should prevent it from becoming a hindrance. Even in a discussion of research any rule of thumb will only mislead us, while headwork is constantly necessary.

The distinction which he draws is not between things done; the electrical engineer, as he says, may work to remove an objectionable feature in electric lamps, while the man of pure science may investigate precisely the same phenomenon in precisely the same manner for the entirely different purpose of obtaining an explanation of a physical occurrence, the nature of which cannot be explained by known facts. The only difference in the work of the two men is one of motive. As another indication of this division we quote from his presidential address at the thirty-third annual convention of the American Institute of Electrical Engineers in Cleveland.

"The investigator in pure science," he said, "may be likened to the explorer who discovers new continents and islands or hitherto unknown territory. He is continually seeking to extend the boundaries of knowledge.

"The investigator in industrial research may be compared to the pioneers who survey the newly-discovered territory in the endeavor to locate its mineral resources, determine the extent of its forests and the location of its arable land, and in other ways precede the settlers and prepare for their occupation of the new territory."

As the same gentleman stated on another occasion, "I would not try to divide science up into two kinds, but rather divide research into two kinds—that is, research conducted from a pure science motive, and research con-

ducted with the applied science motive. The ethics and methods of procedure in these two cases are in many respects conflicting when this distinction is not made. When the distinction is made, the conflict disappears and harmonious co-operation is obtained."

Now temperament will guide motives better than motives will guide temperament, and with the division made, as Dr. CARTY would have it, the two fields call for different temperaments. The man who works in pure science must have what he calls the Divine Spark and what we are disposed to call the Gift of Curiosity, to make him persevere as a seeker after the truth; who can sense what HUXLEY called "the supreme delight of extending the realm of law and order ever further toward the unattainable goals of the infinitely great and the infinitely small, between which our little race of life is run."

We must be constantly on our guard not to let the distinction run away with us, or to draw from it such conclusions as were not intended. Nothing was further from Dr. CARTY's thought than the abolition of engineering and technical schools. Engineering is a profession which has to do with the application of science, and this profession has certain fundamental principles which require study before practice. The distinction has to do with research only, and not with the practical training of students, which is greatly to be desired. His point is that in research it is pure science that should be the field for institutions of learning; that specific problems in industry, if worked out in university laboratories, narrow the general field of study for those under instruction and call for more intimate contacts between laboratory and plant than are possible in universities; that the frank and free exposition of needs, costs, applications, etc., is not so available to the university staff and students as to the industrial laboratory, whether privately supported or privately retained.

Therefore, without desiring to put a brake on progress, he would make a division wherever possible—allot the fundamental problems, the questions in pure science, to the universities, and support them generously. This he regards as a legitimate expenditure by corporations and firms. It is work which universities are peculiarly fitted to perform. The vast number of undetermined chemical and physical constants that are needed almost more than anything else and which are so slow in coming out are within this domain, and university laboratories all over the country should be busy with them. The industries could well afford to pay for it.

Apart from this, however, the general fields of the unknown are so very great that, as a scientific nation, we need this constant study and research in pure science for the inspiration of progress. If the universities look too hard for practical uses; if utility is the motive rather than the all-embracing curiosity to increase the boundaries of knowledge, then the scope of research is

bound to be so restricted that we shall miss the big things. In other words, whenever in pure science we want to be too practical we put on blinders.

This is the trend of thought we read in Dr. CARTY's various utterances and in which we heartily concur. It is opposed to an equally earnest disposition on the part of others to co-ordinate universities and industries so that, to use a popular expression, they interlock.

If universities are to become great consulting establishments, they must adjust their work to problems of consultation. Here we return to the question of motive. A great industrial consulting and research establishment must have service to industry as its primary motive. If it attempts to train students, the motive to train them must become secondary and not primary; and if students are trained "on the side," as it were, their training is likely to suffer. While it is very desirable for professors of pure science to get out into the industries to see their science applied, their real business is to teach fundamentals and research in pure science.

Sursum Corda

IN AN article on "The Future of the Cotton Industry" in a late number of the *Atlantic Monthly*, Professor MELVIN T. COPELAND of Harvard University tells how the prestige of English cotton mills has been endangered during the last year from a cause which is all too familiar over here, but which applies to other industries as well as to textile mills.

"As a result of the inflation of values," he says, "arising from credit and currency conditions in England, the nominal worth of cotton mills rose far above their original cost. Financial promoters grasped the opportunity to enter the industry. Mills were purchased at what, in the long run, is likely to prove exorbitant prices. Amalgamations of mills have been formed that we should call 'trusts' with heavy capitalization." They have grown beyond manageable size. Heretofore managers of mills have been part owners. They were competent, and the overhead expense for good management was slight. As partners they gave time and divided profits. With the sale of the properties these experienced managers have been supplanted and the establishments have grown too big for the eye of any other master than an industrial genius. The need to pay dividends on excessive capitalization works against proper maintenance and upkeep. This same excessive capitalization increases unrest among the workers of the mills, and the industry is thoroughly unionized, with fifty years' experience in collective bargaining. Then follow troubles and strikes and losses and the discouragement of other investors.

We have had so much experience with this very type of mismanagement of industry in this country that no warning should be needed, but it seems to be, all the time. Just because great corporations organized with scrupulous care do succeed occasionally is no reason why loosely jointed units should make for consolidated success. The incidence of greatest fault is usually upon so-called investment bankers who do not know one industry from another. The consolidation of interests into great corporations is sound only when all the talent and interest is held close to every job and all the fear of making mistakes is kept alive in the heart of every department chief while at the same time encouragement for work well done is constantly studied and applied.

Sursum corda, lift up your hearts, is an old ecclesiastical shibboleth, but it is needed in industry as well. As soon as it weakens, as soon as the men engaged cease to feel the inspiration that they are responsible parts of something alive and vital, their hearts sink. Then somebody else with a small establishment that he understands and can manage well and who has his heart in his work will naturally undermine the big concern and get its business.

Opportunity for Engineer-Citizens

THOUGHTFUL readers will be impressed, if not depressed, at the revelations made by RAYMOND B. FOSDICK in his book on American Police Systems. Whenever we are disposed to let the eagle scream and thank the LORD that we are better than other folks, it may be worth while for our own illumination and better understanding to ponder over a few of the statistics which the book contains. We present a few of his figures without further introduction:

In 1918 the arrests made in Boston, Philadelphia, Chicago and New York exceeded those made in London during the same year by 32,520, 20,005, 61,874 and 111,877, respectively. In 1919 there were 5,527 automobiles stolen in New York against 290 in London and ten in Liverpool—better than fifteen a day in New York as against less than one a day in London and Liverpool. In 1918 the ratio of robberies in London to those in Chicago was as 1 to 22, and there were in that time fourteen robberies in Chicago to every one in all of England and Wales. But not only have New York and Chicago been wallowing in the muck of misgovernment during the past few years, achieving such unhappy distinction. There's Los Angeles, that had in 1916 sixty-four more robberies than England, Scotland and Wales combined. Cleveland has three-fourths the population of Liverpool, and last year reported thirty-one times as many robberies. In 1917 Chicago had more murders than England, Scotland and Wales together.

"Well," as the late WILLIAM M. TWEED asked, "what are you going to do about it?" What shall we do? Go right on boasting and bragging and letting things go to the devil? Haven't we as engineer-citizens any responsibilities? The majority of crimes are committed by young men; men under twenty-five years of age, as we recall it. A few years ago these boys were toddling about the streets; most of them in this country. Those that were born abroad might not have engaged in careers of crime if they had not come over. The fact that they did engage in crime here is our fault. It's pretty hard to tell just what the fault is, but it rests upon us all. In a little while the boys that are now toddling about the streets will have reached the criminal age, and their ideals are at present in the making. Have we any means of molding these ideals into good citizenship? If we have, isn't it about time we began to think about doing some of this molding and getting it done?

One thing is certain, and that is that we can't lead these young criminals into enlightenment by legislation. The more laws we make the more they'll break. The most hopeful means now available seems to be in the organization of boys' clubs, plenty of boys' clubs, under competent supervision. An immense number of these are needed, and they can't be run by machinery; they

require, each, a sympathetic, firm, intelligent and sporty director. One of the best and most successful leaders of boys we know is a chemical and metallurgical engineer whose hobby is good citizenship through the Boy Scouts movement. Other engineers might follow his example with profit to themselves and the community. Given the right men in charge, gangs disappear from the neighborhood. The gang is the principal nursery for our criminals.

Efficiency in Freight Movement

WHAT a diversity of counsels there is with respect to our railroads! There are those who argue that now is the time for the railroads to buy, so as to act as business stabilizers. There are others who insist that now is the time for the railroads to economize and develop efficiency. In one quarter it is urged that shippers should ship now if they can, for later there may be great delays. In other quarters the feeling prevails that the heavy freight rate advances of last August were accepted cheerfully by the public because they promised better freight service, so that consumers would not need to carry stocks.

One of the chief sources of trouble is that many people have ulterior motives. They think of the railroads not as servants of the public but as patrons. They are less interested in seeing the railroads furnish good service than in seeing them place large orders. They have noticed in the past that when railroads were large buyers business was good, hence they assumed that these things stood in the relation of cause and effect. If it is a case of *post hoc, ergo propter hoc*, it would be more to the point to note that every industrial depression we have had has been preceded by a period of marked railroad expansion, either in building new road or in adding to equipment.

In our issue of Nov. 10, 1920, reference was made to our troubles about coal, the explanation proposed being that the coal industry had grown so large that it could not grow the way people wanted it to because it was beginning to interfere with other industries. This same principle applies to railroading, and will apply to any activity in similar circumstances. In fact, the principle applies even more pointedly to railroading than to coal mining, for as indicated in the discussion as to coal the rate of increase in production and consumption has been tending to decrease, whereas in railroading the rate of increase in freight ton-mileage has shown no signs of coming down.

All along the line, moreover, the tendency in the past few years has been for men connected with the railroad service, whether on the railroads or in shops serving the railroads, to do less work. Incidentally there are the full crew laws, the Adamson law and the abolition of piece work. Last summer there was loud complaint that railroad service was insufficient. We could not build enough roads because road material was lacking, we could not build enough automobiles, we could not make enough steel, we could not do enough anything, because we hadn't enough railroad facilities to move freight. Yet everybody was at work. There were more jobs than men. What would have occurred if there had been twice as much railroad capacity? There might have been twice as many jobs, but there would have been still fewer men working at the jobs, because more would have been working at railroad jobs.

Obviously, then, what is needed is more efficiency at both ends. The railroads should handle more freight per unit of equipment and per man employed, and the public should get along with less freight movement in proportion to its industrial activity.

Conversion of Sawdust Into Cattle Feed

ON ANOTHER page E. C. SHERRARD tells of his experiments in making cattle feed from sawdust, which is interesting from several points of view. He secures a conversion of about 20 per cent of the wood into sugar, which seems large from the published records of the producers of alcohol from this source. It would be interesting to know how large a part of these sugars is fermentable. The extraction of the sugars from the digested dust and the evaporation of the sugar solution to a thick sirup are processes which, it would appear, might be done at the sawmills, whether the product is to be fed or fermented. Mixing the sirup with the wood residue seems to indicate a plentiful and eventually a cheap fodder, for the cows get all there is to the sawdust, while nothing but the moisture in the mixture is wasted.

When the fodder consisting of 26 per cent of hydrolyzed sawdust was administered, the cows gave an increased production of butter fat and they gained markedly in weight. The "wood meal" was substituted for barley in the ratio of 2 to 1, the cattle obtaining their protein from the other parts of their ration which was mixed with it, for the protein content of sawdust is admittedly light.

The experiment was made with Eastern white pine. We have no idea what would happen if hemlock or oak sawdust were used. Maybe the pine wood meal contains some kind of vitamine that makes cows give milk, although Mr. SHERRARD doesn't say so. That the cows were fed by the "reversal method" worried us until we discovered that *reversal* is a stock breeder's technical expression for *alternating*.

The Chemical Engineer And the Human Viewpoint

IT IS SAID of many chemists and other scientific men that they are lacking in an appreciation of human relations, that they are unsociable and that they need a training in personal salesmanship. This cannot be true of the successful chemical engineer. If he is to carry the ideal of winning the top notch for the benefit of chemistry to the industries he must have, above all knowledge of the phases of business, a human sympathy and understanding of men.

This has been said before regarding success in other ways, but it should be practiced. The man in the plant does well to lunch with the laborers, discuss with them the things of interest in their lives. It is entertaining as well as profitable. Some practical philosophy may be instilled by conversation but without preaching. If a wheel becomes stuck during the work, the chemist may well throw in his shoulder, even though he may dirty his Sunday clothes. Later on when gentlemen are subordinates on his staff he will have acquired the ability to be kind and considerate. The main difference between the office man and the laborer is a mighty thin polish. Elementally, they are alike. Finally, when subordinates feel that the executive chemist is with them, he is qualified to sit in high places.

Readers' Views and Comments

Electric Furnace Refractories

To the Editor of Chemical & Metallurgical Engineering

SIR:—Referring to Mr. Greaves-Walker's reply to my comments on "Electric Furnace Refractories" (CHEMICAL & METALLURGICAL ENGINEERING, Dec. 22, 1920, vol. 23, p. 1196), I am sorry that Mr. Walker received the impression that I intended to ignore the existence of certain dead-burning plants in the Eastern United States which were put into operation before the plant of the Northwest Magnesite Co. Such was not my intention, as I was referring to magnesite producers and the Northwest Magnesite Co. was the first magnesite producer to erect a dead-burning plant at the mine.

The plants to which Mr. Greaves-Walker refers ceased operations when the Northwest Magnesite Co. began producing dead-burned magnesite, because there was no economic reason for their existence. If they burned crude magnesite they would have to pay freight on the CO₂ gas shipped into the plant, and if they reburned calcined magnesite they would have to stand the cost of a second handling and burning. Aside from any other considerations, therefore, their operation was impractical as soon as properly made dead-burned magnesite was produced at the mine. ROBERT D. PIKE.

San Francisco, Cal.

Relationship Between Segregation and Rail Failures

To the Editor of Chemical & Metallurgical Engineering

SIR:—Dr. Burgess' recent series of articles on comparative rail tests has doubtless aroused considerable interest among your readers, but I do not think you are quite fair to Dr. Burgess in your editorial entitled "Good Rails Are More Than Sulphur Prints." This statement is, of course, true, as Dr. Burgess also would readily admit, but the following statement that all the rails that he tested were good is open to very serious questioning. I would like to emphasize that goodness in a steel rail implies much more than resistance to wear; a worn-out rail can easily be replaced when its appearance shows it has become weak, but the damage done when a good-looking but brittle rail breaks under a fast train is a very serious matter.

It is a great pity that Dr. Burgess' careful testing of these rails was not followed to its logical conclusion of a service test on the basis of safety or resistance to breakage, instead of merely wearing them out by excessively heavy traffic before they had a chance to fail from cracking or fatigue. But the omission of such a test in this case is hardly a good reason for your sweeping criticism of metallographists and testing engineers who have found out by study and experience what defects usually make rails fail in service and who thus feel justified in classing rails without these defects as better than those which contain them. Sulphur prints are probably the most valuable and trustworthy means of showing one of the most dangerous of these defects—namely, segregation. If the drop-test does not reveal these defects clearly, Dr. Burgess has done well in calling attention to its limitations.

Another point which you have apparently failed to

consider, in stating that all the rails tested by Dr. Burgess were good because no failures in track were reported, is that the bad portions of all these rails were cropped off during his careful inspection and search for segregation, piping, etc. It is hardly necessary to state that discards of 60 per cent, or even of 30 per cent, are unheard of in ordinary rail-mill practice, so that in making these discards from the defective ingots the rails which might be expected to break in service were eliminated.

I am in hearty agreement with your statement that Dr. Burgess' tests are "probably the most minute study ever made of a rail rolling," but they are open to the objection from a practical standpoint of having been concentrated on comparatively few ingots and rails. This is admitted in his discussion of "performance in service" on page 1021 of your issue of Nov. 24. On this account I would like to call attention to the series of tests made a few years ago in our laboratories on samples of A-rails from a number of rollings at different mills.

These tests were made to determine the general effect of titanium treatment of rail steel, and the samples were obtained in pairs, the same number of titanium-treated A-rails and of ordinary untreated A-rails being obtained from each mill, from rollings as near together as possible, and with the same top-discard, usually 9 per cent, from both kinds of steel.

Tests made on these rails included chemical analyses, tensile, hardness, impact, endurance and vibratory tests at various parts of the rail section, and also metallographic studies both by macroscopic etchings and by examinations of non-metallic inclusions and microstructures with a microscope.

The average results obtained from the physical tests were as follows:

		Plain Steel	Treated Steel
Elastic limit.....	Head	56,936	59,441
	Flange	57,005	59,841
Tensile strength.....	Head	119,900	125,723
	Flange	121,523	126,370
Elongation.....	Head	12.9	13.5
	Flange	15.3	15.1
Reduction of area.....	Head	14.3	16.0
	Flange	18.4	19.2
Brinell hardness.....	Head	219	224
	Web	249	235
	Flange	215	225
Impact resistance.....	Head	1.48	1.60
	Web	1.11	1.24
	Flange	1.29	1.44
Endurance test.....		20,404,456	27,501,196
Vibratory test.....	Head	1,275	1,252
	Web	919	1,047
	Flange	1,310	1,236

We determined from these tests that the essential improvement obtained by titanium treatment consisted in the elimination of segregation, without any simultaneous contamination of the steel by a deoxidation product such as alumina or silicates. We then made a much more extensive test of smaller samples of A-rails, both treated and untreated, to determine how general and infallible this action of our alloy on segregation was. This investigation was made by sulphur prints

and by chemical determinations of carbon at an upper corner of the head and just above the junction of head and web. Excessive segregation, accompanied by a streaky condition as indicated by sulphur prints, was found surprisingly prevalent among the samples examined from 111 different heats of ordinary untreated steel, but it was rare among the titanium-treated samples, which came from 101 different heats.

	Plain Steel	Treated Steel
Total number of heats.....	111	101
Number with less than 1 per cent segregation.....	6	29
Number with 1 per cent to 12 per cent segregation.....	34	65
Number with 12 per cent to 20 per cent segregation.....	27	5
Number with over 20 per cent segregation.....	44	2

We have continued our work in examining numerous other heats of titanium-treated steel for segregation, and we still find it rare in this class of steel. We have found, moreover, that no titanium-treated rail is ever segregated if the treatment has been properly made so that there is a small residual content of titanium. Segregated titanium-treated A-rails always show a titanium content below this required minimum. We feel that this is rather an important discovery, affording a simple practical test whereby the purchaser of steel rails may be assured that his material is free from segregation.

I would like to emphasize the above in comparison with Dr. Burgess' results on segregation. From the thirty-six sink-head ingots, seven of the A-rails showed over 20 per cent segregation and seven others showed between 12 and 20 per cent. In other words, 42 per cent of the sink-head A-rails showed over 12 per cent segregation, while only 7 per cent of our titanium-treated A-rails were similarly segregated. The average discard necessary for segregation from the sink-head ingots was 11.5 per cent, while our titanium-treated samples were cut after an average discard of 9 per cent. It is true that the Maryland comparison ingots killed with aluminum required a smaller discard for segregation than 9 per cent, but their additional discard for pipe was excessive. Theoretically there is no question that the sink-head process is effective in eliminating pipe from ingots, but piping can be controlled also by care in the ordinary methods of ingot manufacture. For instance, in a recent rolling of standard titanium-treated rails, the top discard averaged 8.3 per cent from the ingot, and by keeping the silicon content of the steel below 0.10 per cent and pouring the ingots slowly, the piped rails were kept down to 4.5 per cent, as determined by the nick-and-break test on every ingot. No special molds or hot-tops were used.

It has been brought out by some of the American Railway Engineering Association's reports and those of the bureau of safety of the Interstate Commerce Commission, that split heads and webs, which constitute about half of the causes of rail failures, are due to segregated streaks and generally occur in the A-rails. This, of course, is the reason why it is so important from the standpoint of safety to eliminate segregation from rails. The head failures for 1919 constitute over half of the total. An I. C. C. committee has recently reported that "seaminess plays an important part in many rail failures, the elimination of which or partial

success in their avoidance should reduce the number of failures." This seaminess has been shown to be merely a form of segregation and is nearly always indicated by sulphur prints of ordinary A-rails. "Accident Bulletin No. 84" of the Interstate Commerce Commission states that 631 accidents in 1919 were attributable to broken rails and ten persons were killed in them. Of the rail accidents whose detailed causes are given, almost 70 per cent were due to "crushed heads, split heads or split webs," all the result of segregated steel without much doubt. The practical importance of avoiding segregation in steel rails should therefore be evident to all.

We are in a somewhat stronger position than Dr. Burgess in regard to actual service tests, for all the titanium-treated rails that we examined for segregation with the results noted above have been in track long enough to give an accurate idea of their average endurance. We have taken all these service records directly from the rail failure statistics of the A.R.E.A. The average data taken from the 1918 report for open-hearth steel only will be given here. The average failures per year in service per 100 track-miles were 6.8 for all titanium-treated open-hearth rails. For ordinary untreated rails the best showing from any mill was 8.7 failures per year in service per 100 track-miles, and this was for rails from a mill where it is understood the A-rails are discarded and rolled into small bars for miscellaneous uses. The records from other mills for untreated rails were 9.0, 12.7, 14.0, 15.0, 15.2, 15.3, 16.3, 16.5 and 26.2 respectively, the average record for all untreated rails being 14.3. Thus the failures in service of titanium-treated open-hearth rails were only 48 per cent of those for ordinary untreated open-hearth rails, which proves that by eliminating segregation we have indeed prevented half the rail failures.

Since the above data were tabulated, the rail failure statistics for 1919 have been published, and we find a different set of figures, since these reports cover only the rails that have been in track for five years or less, and hence each year the oldest lots from the year before are dropped. Also in this report the bessemer and open-hearth rails are grouped together and not kept separate as formerly. Six lots of titanium-treated rails are included in this report, and four of them stood five years' service with no failures, one stood four years' service with no failures, and one stood five years' service with thirteen failures, nearly all of which were flange breaks or clean transverse fractures, as reported to us by the railroad. These failures average up to the very low figure of 3.3 per 100 track-miles per year. Two lots of sink-head ingots are also shown in these rail failure statistics, one of them giving twenty failures in five years' service and the other eleven failures in four years, making an average of 12.2 failures per 100 track-miles per year. The averages for all rails from the various mills were respectively as follows: 8.4, 8.5, 11.9, 12.0, 13.4, 15.6, 19.3, 19.4, 22.5 and 41.7, giving a grand average of 14.7. The showing for the sink-head ingots is thus very little better than the average, while the titanium-treated steel showed only about one-fourth of the average number of failures per 100 track-miles per year and less than half as many as the ordinary rails from the mill that had the best record of all.

GEORGE F. COMSTOCK,
Metallurgical Engineer,
Titanium Alloy Manufacturing Co.

Niagara Falls, N. Y.



Old Laboratory Building

RESEARCH LABORATORIES AT SHADYSIDE, EDGEWATER, N. J.

Wooden Experimental Buildings

New Laboratory Building

Coal-Tar Research at Shadyside

An Account of the Expansion of the Scope and Facilities of the Research Department of The Barrett Company—Study of Physical Properties, Methods of Testing and Development of Synthetic Products

BY JOHN MORRIS WEISS AND CHARLES RAYMOND DOWNS

A STUDY of the recent *Bulletin* of the National Research Council by A. D. Flinn entitled "Research Laboratories in Industrial Establishments in the United States of America" is indeed gratifying, as it indicates the widespread appreciation of research by the industries of the country. Industrial research laboratories have greatly increased in numbers and size in the last few years. The great improvements in both quality and diversity of products already evident should result in accelerating advances in the near future as these laboratories gain more experience in attacking the problems vital to the betterment of national security and independence.

To accomplish this desirable objective it is imperative that the brilliant young minds of the country appreciate the fascinating game of research and be attracted to it in proportion to its importance as a national insurance. It is also vital for the faculties of our universities to realize that in the past they have been perhaps too prone to evaluate their students upon the basis of memory and upon parrot-like repetitions of the contents of textbooks. Chemical research needs men with creative imagination who are sufficiently familiar with the work of the past so that new advances can be made by studying the effect of materials under new conditions, by examining common materials with improved instruments, by the study of manufacturing wastes, by noting and developing the byproducts of research which may be of more importance than the objective originally conceived.

Many of the most important discoveries of science have been so-called accidental, but had the power of observation and creative imagination been lacking they would have remained unknown for generations. We must admit that a knowledge of the literature is of very great importance, but that even the simplest experiments

reported in the past may have produced an important unrecognized byproduct. For the proper prosecution of such work the mind running in a groove along conventional lines is unproductive of revolutionary discoveries.

We therefore cannot rate or compare industrial research or any other research laboratories by the number of men employed or by the imposing expenditures of money assigned to their construction. Men trained in the fundamental principles of science and retaining mobile, plastic minds are the great unfilled need. The progressive industries are ready enough to supply the proper laboratory equipment and the business organization of the laboratory to relieve the research man of the executive and routine details.

PHYSICAL STUDY OF COAL TARS

The coal-tar business touches in some more or less personal way a great proportion of the manufacturing of modern civilization, and its scope is broadening daily. We have only a dim appreciation of its possibilities even after 150 years of destructive distillation of coal. The officers of The Barrett Co. sensed that there were still great potential treasures locked in the dingy tar vault and that long sustained attack would conquer the vault combination. The process of picking this lock is a fascinating problem and it is only partly solved, although numerous tumblers have shot home during the history of coal-tar chemistry.

In 1911 The Barrett Co. made a small beginning at a systematic study of the research problems connected with coal-tar industry when it established a research department. In the initial stages the work naturally concerned itself with the study of tars obtained from different sources and made by distilling coals in various ways. A large amount of data was collected along these lines. Such data are essential to the proper utilization

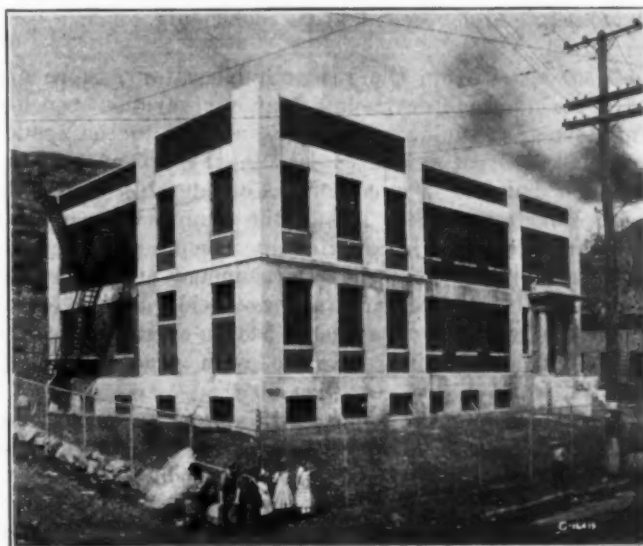
of tar in the manufacture of cruder products, so that tars can be properly blended before distillation to obtain desirable properties in either the residuals or the distillates. Further, in the production of the more refined products, the nature of the crude tars often predetermines their adaptability and use for the manufacture of such products. As the properties of coal tars are continually changing, depending upon the economic conditions which influence the methods of coal carbonization, this problem is a continued one and studies along this line will probably be a permanent part of work in coal-tar chemistry so long as such changes take place.

Naturally also a considerable amount of study was and is being given to the development of suitable testing methods for tars and the various primary materials separated from tars. Many of these testing methods have been described by one of the authors in the *Journal of Industrial and Engineering Chemistry* of September, October, November and December, 1918, and a number of these methods have been accepted by the American Society for Testing Materials, the American Gas Institute and other technical associations in a substantially unchanged form.

SYNTHETIC CHEMICAL INVESTIGATIONS

As to the work along more strictly chemical lines it is, of course, impossible in a paper of this sort to give very much detail, as naturally such work is of a decidedly confidential nature, so that we can give merely a few examples of developments which will indicate the considerable scope and breadth of the work carried out in the research department of The Barrett Co. Among developments which have reached a full manufacturing scale are: the complete synthesis of alizarin or turkey red; the synthesis of phenylglycine, an intermediate for the manufacture of indigo; and resorcinol, used largely in dyes and hair tonics. The development of catalytic oxidation processes have recently resulted in new manufacturing methods for the production of anthraquinone, phthalic anhydride, maleic, fumaric and malic acids, and these are all being manufactured on a small scale somewhat beyond the experimental laboratory stage.

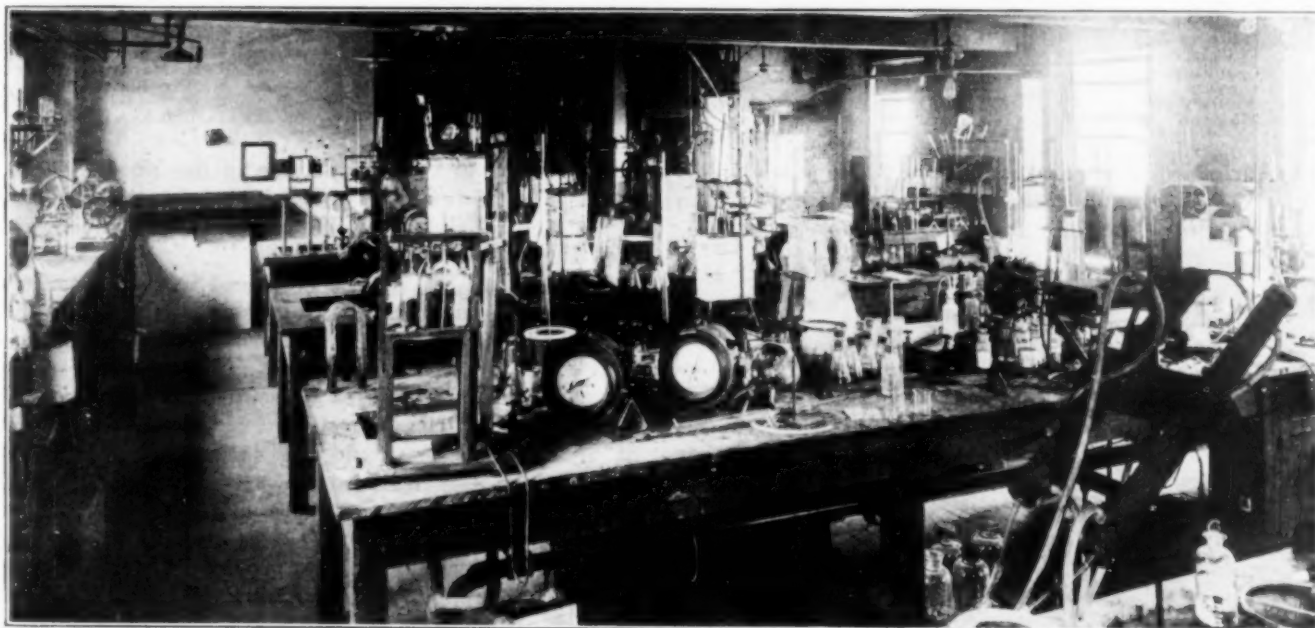
In addition to the work at the research laboratory



NEW LABORATORY BUILDING, ENTRANCE TO BE CENTER OF COMPLETED STRUCTURE

much work has also been done at the laboratory of our chemical department in Frankford, where the Dennis-Bull process for the manufacture of synthetic phenol was developed. Products such as orthocresol, Cumar (coumarone resin) and alpha-naphthylamine have been developed and produced on a large scale. The development of column distillation made it possible to separate orthoxylene from the meta- and para-isomers and produce this as a commercial product. Much investigation has been done on improvements in the manufacture of naphthalene and in the production of high-purity anthracene, carbazol and phenanthrene.

Similarly, methylnaphthalenes, acenaphthene and fluorene have been produced, these awaiting only commercial uses to make their production an accomplished fact. Synthetic tanstuffs have been studied and several grades of satisfactory commercial quality are being manufactured. Another branch of the work of a very different nature has been in the development of disinfectants, which requires bacteriological work as well as chemical work. As a result disinfectants of



LABORATORY IN OLD BUILDING

extremely high germicidal coefficients have been produced.

Also, apart from the research laboratory, there has been considerable development at our various branches in the manufacturing methods as applied to the cruder products. Great improvements in the art of tar distillation have been recorded. Considerable work has been done on paper, as in the manufacture of our saturated felts we have naturally become paper manufacturers on a large scale. Development and investigation have been necessary in these fields and in all of them the research department has co-operated both in an advisory capacity and also with practical experimental work.

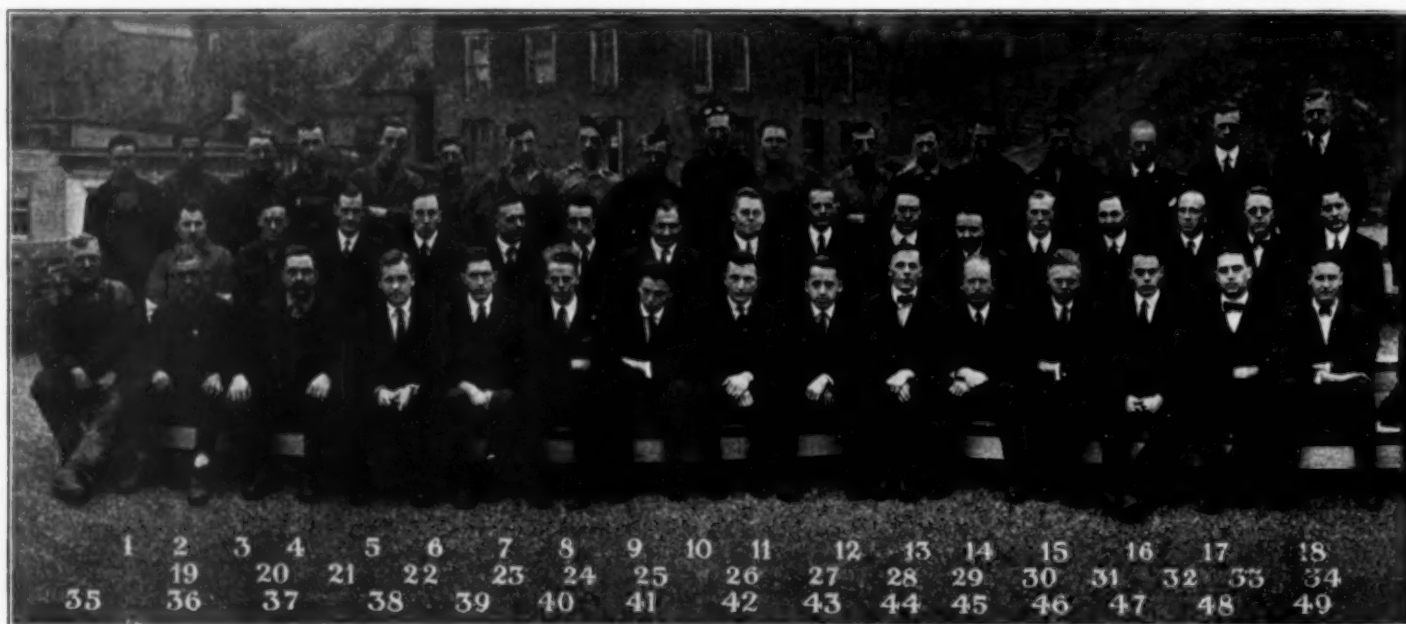
As a byproduct of some of this work, a centrifugal machine has been developed whereby bituminous materials and other products can be produced in hair or

present there is a total force of about 100 men in the research department.

Although all of the buildings shown in the sketch are in use, we will describe only a few of the salient points of the new research laboratory. It is built of reinforced concrete with tapestry brick panels.

THE NEW LABORATORY BUILDING

The front member of the L form comprises the office section and is separated from the laboratories, which are situated in the other member of the L, by rolling shutter fire doors released by fusible links. In addition to the fire escapes prescribed by law there is a fire balcony connecting the windows of the various laboratories above the first floor, so that egress is provided from each room both by the doors leading to the corridors and by the windows. Every laboratory in which



STAFF OF THE RESEARCH DEPARTMENT

1. A. Murray
2. T. Nunci
3. R. Weston
4. E. Fay
5. J. McDonough
6. G. Bender
7. J. McCurry
8. L. Pawson
9. J. Gronning
10. F. Curran
11. F. Favre
12. A. Magrino

13. C. Schlick
14. C. Curran
15. F. Zimmerman
16. J. H. Timken
17. F. W. Wagner
18. O. F. Richter
19. V. Maraldo
20. M. Magrino
21. A. Allwood
22. R. Penfield
23. O. Stein
24. W. Wilson

25. H. Kolbe
26. E. H. Lane
27. F. W. Yeager
28. L. Welsberg
29. A. E. Craver
30. W. H. Rile
31. R. M. Strong
32. C. S. Reeve
33. H. G. Sidebottom
34. J. M. Weiss
35. G. Rittenger
36. P. Favre

37. A. Esik
38. F. Spindler
39. A. W. Tracy
40. D. Hageman
41. J. N. Simmonds
42. C. W. Fisher
43. S. C. Levy
44. E. D. Punnet
45. J. H. Mackintosh
46. R. Voorhis
47. E. G. Wadel
48. R. Brooks

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shot form. This apparatus is applicable to other substances with suitable melting points and forms a very excellent means of subdivision and cooling.

EXPANSION OF THE RESEARCH DEPARTMENT

Today the tendency is to centralize as far as practicable as much as possible of the varied work at the laboratories of the research department. These have expanded in size from 816 sq.ft. floor area in 1915 to 29,000 sq.ft. in 1920, the comparison being shown in a figure accompanying this article. The sketches do not include some experimental plant buildings which are at present occupied actively on research problems. The new laboratory, built in 1920, is laid out for a possible expansion to a total of 54,000 sq.ft. of floor space, allowing for the accommodation of more than 210 working laboratory chemists in addition to other chemists and chemical engineers in the experimental plants. At

flammable organic materials are in use should be provided with two exits, as a fire may take place in front of one and thus block off the escape of the occupants in that direction.

Shower bath heads are also placed in each laboratory room for the purpose of extinguishing burning clothing or for removing splashes of corrosive liquids. These are provided with chains fastened to a pipe cross-bar so that the water may be released without difficulty in times of accidents. No drain is provided in the floor, as the use of these showers should be very infrequent. Fire blankets are also provided on vertical rollers similar to window-shade rollers so that a man can wrap himself with the least loss of time. A trained fire department and first aid committee are provided. All laboratory rooms are supplied with Foamite and Pyrene extinguishers, sand pails and fire horns, by means of which equipment practically every small fire can be controlled.

The table frames are made of cypress timbers. The floors of the laboratories are of maple laid over concrete. This sort of construction permits simple fastening and staying of miscellaneous semi-fixed apparatus. Alberene tops are used on the tables. The walls are of Pyrobar, plastered and painted with Toch's White Enamel Laboratory Paint. These walls will hold nails, hence shelves or miscellaneous small apparatus may be easily erected without resort to drilling and the use of expansion bolts. After removal of a shelf the holes are easily patched. Glass partitions of standard construction are used throughout for the offices.

Much care was exercised to provide efficient lighting for the new laboratory. The windows are large, being 6 ft. 7 in. high by 4 ft. 2 in. wide. For the artificial lighting the lamps are placed in relation to the tables so that the worker does not work in his own shadow. The

arrangement prevents the ingress of dust from the outside. Outlet for the foul air is provided through the hoods.

Each hood is provided with a separate exhaustor and this discharges directly through the wall of the building to the outside, thus obviating the carrying of large exhaust ducts throughout the building with their liability of corrosion. Only under extreme conditions is there any necessity for operating the individual hood exhausters, as the air supplied by the ventilating system induces sufficient draft through the hoods.

All of the piping in the building is exposed and easily accessible in case repairs are necessary. The piping system comprises drains, hot and cold water, compressed air, gas and high- and low-pressure steam. Portions of the pipes and valves are painted with distinctive colors denoting their use. Such practice allows of quick shut-



STAFF OF THE RESEARCH DEPARTMENT

49. D. North
50. J. Breckley
51. H. H. Clark
52. L. H. Helfrich
53. J. Gainey
54. J. Cobleigh
55. J. Travis
56. E. Canavan
57. H. E. Williams
58. M. B. Cook
59. J. O'Neil

60. H. Henderson
61. W. Babcock
62. A. La Monte
63. C. R. Downs
64. C. G. Stupp
65. G. C. Bailey
66. W. M. Bywater
67. A. F. Calvin
68. F. Boettner
69. A. S. Williams
70. F. A. Canon

71. C. B. Mayer
72. M. Chieffo
73. E. M. Bradley
74. J. E. Sikorska
75. I. N. Riddervold
76. R. Riegler
77. P. Cernek
78. F. J. Maddocks
79. L. Lehr
80. E. Werle
81. W. F. Schultz

82. M. Bradley
83. F. W. Stetson
84. J. E. Woodcock
85. H. E. Barae
86. L. E. Porter
87. W. Bossenberg
88. G. Holzhausen
89. R. D. Burdick
90. D. Scott

question of artificial lighting is important so as to obtain sufficient light well distributed without so much concentration in any one place that eye strain will develop from glare. To assist in this desirable objective the wall as the back of wall tables is painted with a black enamel to the height of 2 ft. above the table. Direct illumination is used as the cleaning of the bowls of indirect lighting is too laborious.

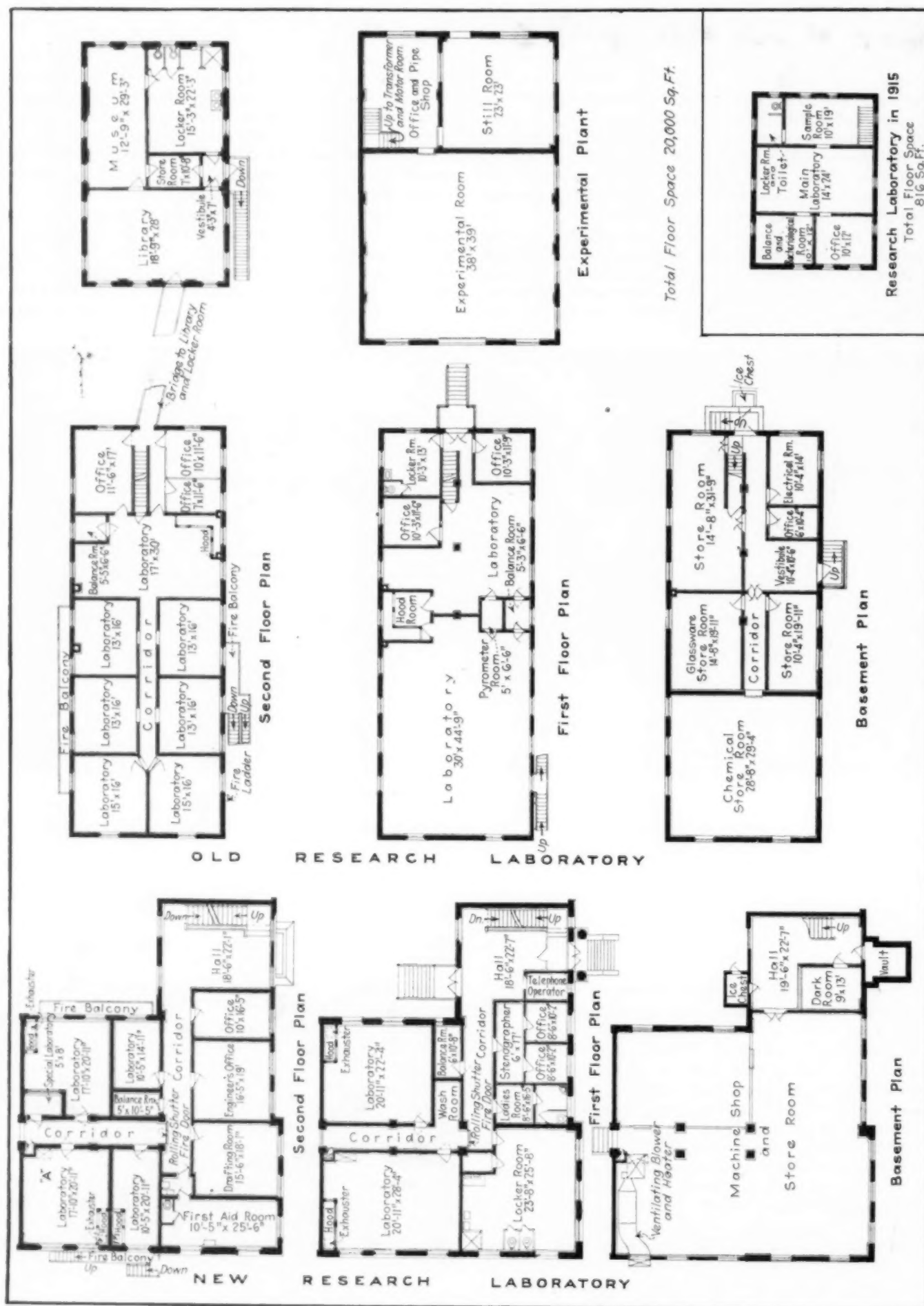
The ventilation of the laboratory rooms is accomplished by discharging into them air heated to 60 deg. F. in cold weather, and whenever additional heating is necessary radiators placed in the individual laboratories may be used. The air of the laboratories is renewed approximately every two minutes and drafts are obviated by special deflectors and by a multiplicity of air inlets wherever needed. There is, therefore, no necessity for open windows and hence the air pressure in the rooms is above the atmospheric pressure. This

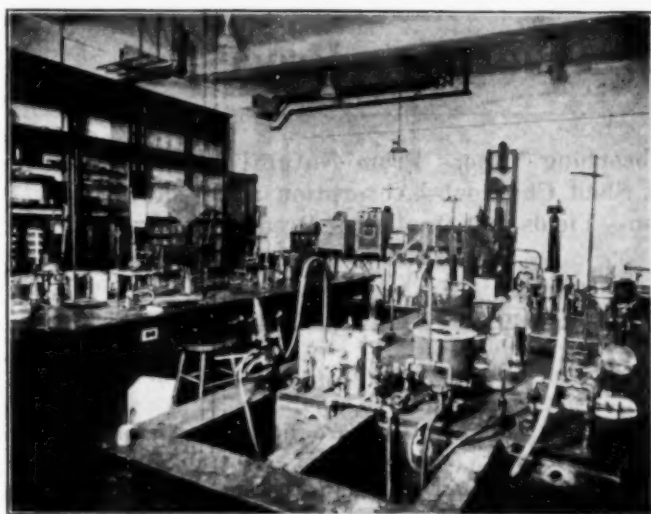
off of gas lines, for instance in case of fire. The tables are provided with numerous electric power plugs for the operation of motors, ovens and the like.

A duct extending from the basement up through the building, denoted in the sketch as A, allows temporary electrical or pipe lines to be brought up to a particular laboratory for specific work which is not cared for by the standard electrical or piping equipment.

Another novel feature is found in room 66, which is provided for the storage of small amounts of flammable solvents used in the laboratories adjoining. It is provided with steam and hot and cold water for the distillation of very flammable materials, such as ether. A transparent wire glass partition separates it from room 65.

There are both temporary and permanent experimental plant buildings, one of the latter being shown in the sketch. This is equipped with vacuum, com-





TYPICAL ROOM IN NEW LABORATORY BUILDING, SHOWING EMERGENCY SHOWER, FIRE BLANKET ROLL, EXPOSED PIPING OVERHEAD AND AIR INLET PORTS

pressed air, gas, water, high- and low-pressure steam lines and floor drains. The headroom is 18 ft. to the eaves and power shafting is hung from the roof beams. Electric power drop cords are also suspended from the roof to take care of electrically-heated portable apparatus. In this building small-scale plant apparatus may be arranged in proper flow relation by framing.

LARGE-SCALE LABORATORIES

Large-scale laboratory work is provided for in one of the experimental plant buildings. The equipment consists of type apparatus not necessarily arranged in a flow relation as would be used in either an experimental or large-scale manufacturing plant. It is used for preparing batches of materials on a scale considerably larger than laboratory practice, so that sufficient material can be produced to determine its application.

DEPARTMENTAL ORGANIZATION

For the proper allocation and handling of the work the laboratory personnel is subdivided at present, under the chief chemist and assistant chief chemist, into five divisions, namely: tar and oil division, organic research, experimental plant, engineering and clerical.

In order to harmonize the working of the laboratory an operating committee composed of the heads of the divisions, the chief chemist and assistant chief chemist and also other members of the divisions whose ability and loyalty warrant their attendance meets one afternoon each week. It considers in more or less detail, depending upon exigencies, the entire work of the department.

The executive committee, made up of the divisional heads, chief chemist and assistant chief chemist, meets for about one hour once a week to consider questions of general welfare and also to provide an opportunity for the chemists to express their opinions concerning the mechanical service supplied.

Seminars are held occasionally where papers are presented either by men in the department or by sales or manufacturing men. Co-operation not only in the department itself but with the rest of the company is earnestly sought and nurtured, and upon this principle depends the success or failure of any of our large, complex, present-day manufacturing organizations.

The hack work of literature searches is well taken care of by a librarian and library chemist, these jointly

preparing bibliographies and abstracts of all articles in a given field, thus placing the chemist in a position to select his reading intelligently and efficiently.

An entirely different type of research and investigation work being carried on by The Barrett Co. is embodied in part of the efforts of the so-called technical service staff. This staff is composed of trained chemists and engineers and its work is directed from the general offices of the company. Its efforts are devoted to technical problems outside our own four walls, determining and developing possible uses for Barrett products, taking the new ideas in the research laboratory to the outside trades, and bringing to the company suggestions of its own as to new products that may be manufactured.

The physical development of our research laboratory is constantly increasing, as we have not only to deal with the production of new materials and the improvement of processes but also with many problems in which the utilization of our products is involved, and as the field into which our products enter is quite varied this work also is naturally quite varied and requires special types of apparatus, particularly adapted to the industries in which our products are used. Coal-tar products and derivatives roof our homes and factories; protect our roads from disintegration and decay; prevent the attack of fungi and marine bores on structural timber; separate ores from accompanying gangue; disinfect our public places and sick rooms; form part of both preventive and curative medicines; color textiles, leathers, inks and what not in our everyday life; waterproof dams, concrete barges, subways and underground conduits; are found in our chewing gums; furnish power in our internal combustion engines whether on land, sea or overhead; comprise a large part of our military and domestic explosives; assist in making up for the lack of natural crude acids for our beverages; protect our structural steel against corrosion; protect our clothes against moths; enter into the composition of our varnishes, of electrical insulators, of clay pigeons, of case hardening compounds for steel treating, of electrodes for arc lights, electrochemical smelting and manufacture of metallic aluminum; are essential constituents of many of the rubber compounds used in various ways; in grinding lenses for our opera glasses, and in fact, enter into almost all phases of our daily life.



VIEW SHOWING HOOD EXHAUSTER, LIGHTING ARRANGEMENTS AND RADIATORS FOR SUPPLYING SECONDARY HEATING

Gasoline by the Charcoal Absorption Process

Description of the Activated Charcoal Process for Absorbing Vapors From Natural Gas—Comparison With Commercial Processes—Activated Coconut Shell Charcoal—Absorption and Selection—Steam Distillation of Saturated Carbon—Yields and Quality of Products

BY G. A. BURRELL, G. G. OBERFELL AND C. L. VORESS

TWO methods of extracting gasoline from natural gas—compression and oil absorption—are now used extensively, while refrigeration is used to a limited extent. The charcoal process, a recent development operating on entirely new and scientific principles, compares most favorably with either of these methods. It produces higher yields and a better grade of gasoline. It does not require heavy initial installation costs and can be operated more cheaply. The apparatus has longer life and is not subjected to inefficiency due to wear. Its adaptability to field conditions is enhanced by the fact that it operates on either lean or rich gas at either high or low pressures.

This year there will be practically 300,000,000 gal. of gasoline produced from natural gas. Where the salable vapors in the gas are over a gallon per thousand cubic feet, it is possible to recover a considerable proportion by directly compressing and cooling the entire volume of gas. Where the salable vapors in the gas are not so plentiful, it has been the custom to resort to the oil absorption process, which is simply a method whereby the desirable vapors are concentrated by partial fractionation so that pressure and cooling may be effectively applied as in the original compression process. The gas is made to bubble or flow through absorbers where the gas comes in contact with a high-boiling mineral oil or naphtha which absorbs the heavier fractions in excess of the lighter ones. The oil or naphtha is then subjected to steam or direct heat to vaporize again the absorbed fractions so that they may later be condensed by cooling and compression.

DISADVANTAGES OF THE COMPRESSION AND ABSORPTION PROCESSES

There are several features of the present processes which are considered obnoxious by practical operators.

Both the oil absorption and compression systems require considerable pressure. The oil absorption may be used at low pressures, but it is not considered good practice because of the low saturations which must be adhered to. These high pressures are not only expensive to produce but mean large outlays for repairs and renewal of machinery. They also increase the danger of explosions.

Quite a little difficulty is experienced in marketing the product because of the large amount of so-called "wild" vapors which it contains. These vapors are the lower boiling fractions which have been absorbed and condensed in the higher boiling fractions by the compression, cooling and solvent action of the liquid. It has been apparent to many men for some time that a method whereby a sharp fractionation could be obtained would eliminate much of this trouble. Methods of hot blending and steam treatment have been used with varying success as a substitute for the original frac-

tation, but all admit that there is still much room for improvement.

The present oil plants are far from simple both in number of units and operation. Constant supervision is necessary if the oil plant is to be operated at as high a degree of efficiency as 75 per cent of gasoline extraction.

From the standpoint of pressures used, of quality of product, of efficiency of extraction, of simplicity of apparatus and operation, and of cost, a new process, one working on an entirely new principle, has been demanded.

CHARCOAL ABSORPTION PROCESS

The charcoal absorption process consists of bringing the natural gas into intimate contact with activated charcoal, in the capillaries of which the vapors are condensed and the dried gas allowed to return to the distribution lines. When a predetermined saturation of absorbed vapors has been attained in the charcoal, the gas is allowed to come into contact with a fresh supply of carbon. The vapors retained in the first mass of charcoal are then evacuated by distilling off with superheated steam, condensed in water-cooled condensers, blended and stored preparatory to marketing. Fig. 1 is a flow sheet diagram of the plant.

ACTIVATED CHARCOAL

The charcoal best suited for the successful operation of the process is made from coconut shells by the steam activation process developed during and since the war. Charcoals made by other methods do not possess sufficient absorptivity to pay for the costs of recovery and therefore are of no use in this process. Even at the close of the war, the better grades of charcoal, those testing from fifty to sixty minutes by the accelerated chlorpicrin test, had not been produced in quantity.

Any charcoal suitable for absorption of vapors from gas must be capable of readily condensing and retaining large quantities of liquid in capillary equilibrium with its vapor and at the same time offer a minimum resistance against recovery. It has been found when applied to gasoline production, if coconut charcoal is activated up to forty, fifty or sixty minutes for the absorption service time, that the retentivity factor tends to decrease above fifty minutes. The curves given in Fig. 2 were obtained with our standard laboratory testing outfit, the glycerine distillation method being used in obtaining the data. It will be noted that there is not a great amount of difference in the maximums of the curves. The big difference is in their decrease in efficiency due to oversaturation. In other words, it is the retentivity function. Fig. 2B shows the same curves corrected for gravity. The twenty-minute material shows a large lack of retentivity, probably due to the shallow capillaries. The fifty-minute

material shows up best here, due no doubt to the capillaries being of the correct size to permit of selection, a term which we shall discuss later. Fifty- to sixty-minute charcoal will absorb from 10 to 15 per cent of its own weight and retain the salable vapors for later recovery.

One very essential feature that the charcoal must possess is what we term selective absorption. Natural gas consists of the gases and vapors of the paraffine hydrocarbon series, the higher members of which have an appreciable vapor pressure at the temperature of the gas. When the gas is first brought into contact with the charcoal the lighter, high-volatile vapors, such as ethane, propane, butane, etc., are absorbed in the capillaries, but as the saturation increases a selection or equilibrium adjustment takes place with the result that these high vapor pressure and undesirable fractions are left in the gas. The heavier fractions are thus isolated and can then be condensed after steam

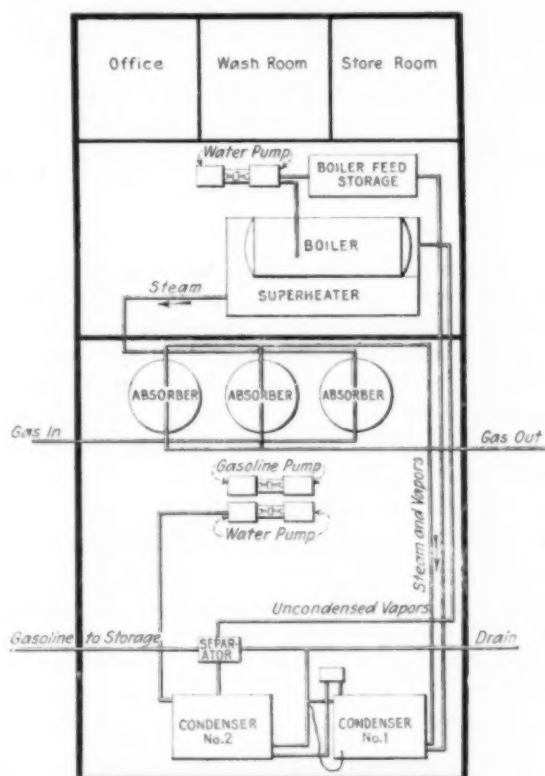


FIG. 1. FLOW SHEET DIAGRAM OF THE PLANT

distillation without the use of high pressures. Regulation of the vapor tension of the final product is thus obtained by preventing the absorption of the higher boiling fractions.

The size of the granules of charcoal should be from 8 to 14 mesh. Smaller mesh material has slightly greater absorbing qualities, but the resistance to the

gas passage rapidly increases as the size of the granules decreases. Gas flowing through a column of charcoal 5 ft. in depth at the rate of 40 cu.ft. per hr. per sq.in. of base surface and flowing against atmospheric pressure will show a retardation of from 1 to 2 lb. due to the charcoal resistance.

ABSORPTION

When natural gas first comes into contact with charcoal considerable heat is developed, which is the latent heat of vaporization from the condensing vapors. After a few minutes the temperature stops rising, which indi-

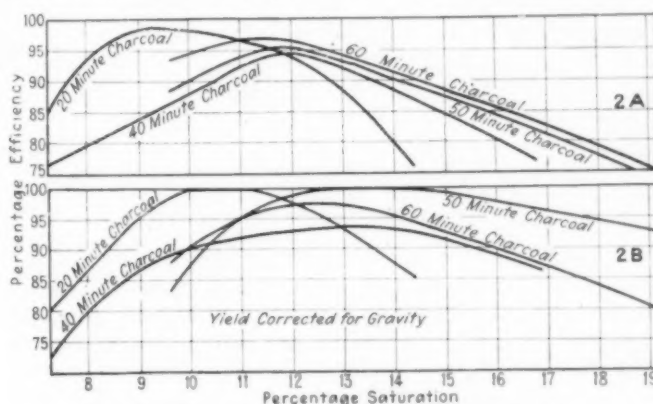


FIG. 2A. CHARCOAL QUALITY CURVES
FIG. 2B. YIELD CORRECTED FOR GRAVITY

cates that selection is taking place and the heat of condensation is being used to re-volatilize the highest condensed liquids, which must be eliminated from the final product. Many investigators have ignored this phenomenon, and have stopped when no more heat evolution was noticeable, thinking that the absorption was complete. With gas rich in vapors we have observed a temperature increase of 60 deg. C. in the charcoal due to the latent heat in condensation. This does not mean that the entire body of charcoal increased 60 deg. simultaneously. The heated volume travels in a zone in the direction in which the gas flows. When using a tube of charcoal $\frac{1}{4}$ in. in diameter and 1 ft. in depth and passing rich gas at the rate of 10 ft. per hr., the heated zone is about 2 in. in depth.

The temperature of the charcoal at the beginning of the gas passage is not very important when using gas of low gasoline content. It quickly gains the temperature of the incoming gas. A loss of about 6 per cent in final recovery was experienced when tests were run with the initial temperature of the charcoal 300 deg. C. However, the temperature of the inflowing gas is more important. Fig. 3 shows that the curve of recoverable efficiency is practically a straight line function of the temperature, other things being constant. This curve reaches its zenith at 300 deg. C. Above that there is no recovery at all.

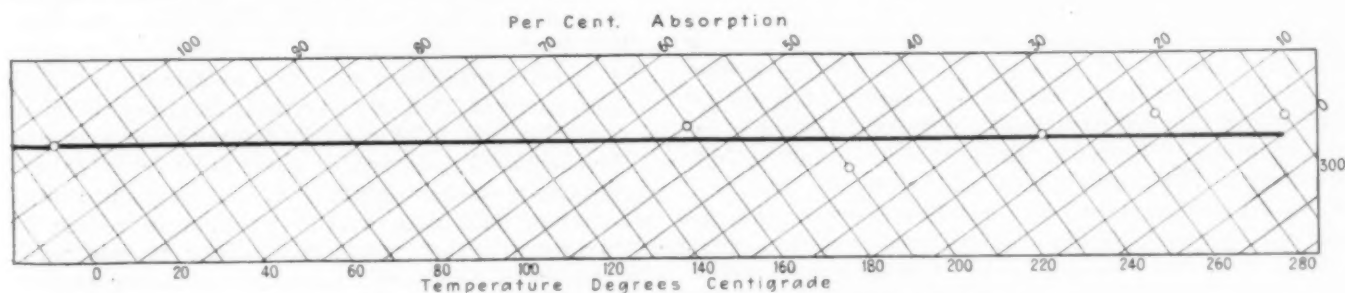


FIG. 3. EFFECT OF TEMPERATURE ON ABSORPTION

TABLE I. HEAT REQUIREMENTS

Weight of gallon gasoline, lb.	5.5
Saturation of 13 per cent by weight required, lb. of charcoal	42.3
Specific heat of charcoal	0.3
Specific heat of gasoline	0.58
Latent heat of gasoline, B.t.u. per lb.	100
Average b.p. of gasoline, deg. F.	210
Highest temperature of distillation, deg. F.	400
Temperature of charcoal by saturated steam, deg. F.	230
Superheat (400 — 230), deg. F.	170
Superheat required for charcoal ($42.3 \times 0.3 \times 170$)	2,157
Heat to raise charcoal 60 to 230 deg. F.	170
Heat required to raise charcoal 60 to 230 ($42.3 \times 0.3 \times 170$)	2,157
Distillation of 60 per cent made without superheat.	
Heat required for gasoline distillation (60 to 230 plus latent heat) ($5.5 \times 150 \times 0.58$) + (5.5×100), B.t.u.	1,030
Superheat required for 40 per cent of gasoline distilled	411
Heat required for first 60 per cent distilled, B.t.u.	618
Total heat required to raise to temperature of superheat, B.t.u.	2,775
Total amount superheat required, B.t.u.	2,568
Theoretical amount of heat required, B.t.u.	5,343
Specific heat superheated steam 15 lb. 400 deg. F., B.t.u.	0.5
Superheat available per lb. of steam $0.5 \times (400 - 230)$, B.t.u.	85
$2,568 \div 85$, lb. of water	30.21
Boiler feed water, deg. F.	200
Boiler heat required, (200 to 400 deg. F.), B.t.u. per lb.	1,089
Total amount boiler heat required ($30.21 \times 1,089$), B.t.u.	32,900
Boiler hp. per gal. gasoline per day	0.045

The rate at which absorption takes place varies according to the richness of the gas mixture. For gas yielding 400 gal. of gasoline per million cubic feet, a rate of 40 cu.ft. per sq.in. of base surface in a 5-ft. column of charcoal is not too high a rate. Above this rate the back pressure due to the resistance of the charcoal itself begins to enter as a factor against higher rates. Fig. 4 presents graphically a series of experiments on rates under these conditions.

The volume of gas to be passed is determined by the nature of the product desired by the operator. If he desires a very volatile product, a low saturation of the charcoal must be had so as not to allow selection to eliminate too much butane, etc. If a staple low volatile product is desired, more gas is passed and the selection is carried as far as desired. This determines the nature of the product and will be discussed later. The volume to be passed to secure the maximum yields for the different grades of charcoal may easily be calculated by the curves given in Fig. 2.

DISTILLATION

After absorption has been completed, it is necessary to expel the condensed vapors from the charcoal. This is done by blowing superheated steam directly through the charcoal. The superheat should be as high as local conditions will allow. There will be a decrease in fuel used per gallon of gasoline recovered, as the temperature of the superheated steam is increased up to the point where the radiation factor of the carrying lines and the efficiency factor of the heater itself become so large as to interfere. Local conditions affect this to a great extent. It will be found, however, that under ordinary conditions 250 deg. C. may be maintained with good results.

The amount of steam required depends upon the percentage of the available heat that is utilized. The charcoal must be heated to 200 deg. C. to dispel the heavier fractions of gasoline. This temperature also insures an active absorbent. The work done is mainly derived from the superheat. The accompanying calculations show that theoretically there are about 5,343 B.t.u. of heat required to produce a gallon of gasoline when the saturation is 13 per cent. Table I shows the heat requirements.

The question is repeatedly asked, "Does this steam distillation injure the charcoal for the other absorptions?"

The steam distillation does not injure the absorptive capacity. In fact, it leaves it in a somewhat better condition than dry heating would conduce. The steam drives out gases and absorbed vapors at a somewhat higher temperature than will permit condensation. The first rush of cooling gas will displace the steam and the first condensation will be of the vapors in the gas. Fig. 5 (solid lines) shows the curves for two samples of charcoal, one of which was being used for the first time for gasoline absorption, the other being taken from the large plant after serving ninety-five absorptions and steam distillations.

A sample of charcoal which had been exposed to the air for a month was divided into two equal portions

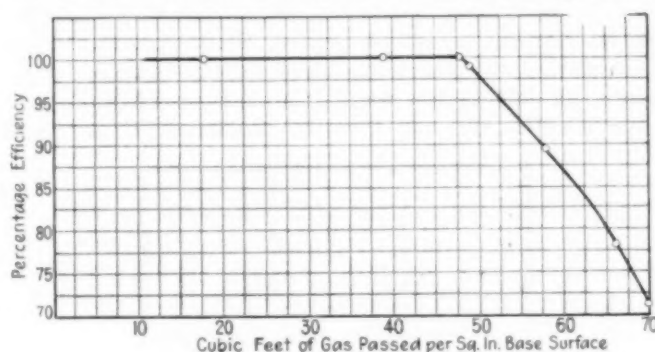


FIG. 4. RATE CURVE

One portion was heated to over 500 deg. C. in an open vessel for more than two hours, and the other was treated to 300 deg. C. with superheated steam. The portion treated with superheated steam exhibits an absorption curve which reaches its peak later and shows more retentivity than the dry heated sample. Fig. 5 (dotted lines) shows the curves for this experiment.

CONDENSATION

The gasoline vapors driven from the absorber with the steam may be condensed in any type of condenser. We prefer two water-cooled condensers in series. The cooling water around the first condenser can be circulated just swiftly enough to condense the major portion of steam and allow for its being trapped away without

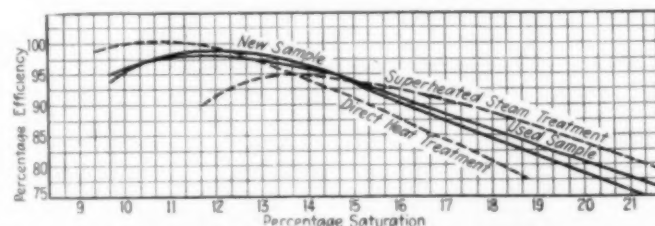


FIG. 5. EFFECT OF USE ON ACTIVATED CHARCOAL (FULL LINES). EFFECT OF DRY HEAT VS. STEAM ON CHARCOAL (DOTTED LINES)

being cooled much under 100 deg. C. In many localities this condenser may well be an air condenser with enough of the line jacketed to heat the boiler feed water.

The second condenser must be an efficient one. With cooling water at 15 deg. C. or thereabout very efficient condensation will take place at atmospheric pressure.

The condensed gasoline and water flows from the condenser into a separating tank. If it is desired to blend the final product with heavier naphtha to reduce its vapor pressure, that may also be done at this point. We prefer to blend with from 10 to 15 per cent of about 56 deg. Bé. naphtha.

An examination of the gasoline produced has brought to light the fact that the gravity and vapor tension of this gasoline is less than the gravity and vapor tension of that made from the same gas by either compression or oil absorption. Fig. 6 is a set of curves illustrating this point. There are several reasons for this. Conditions under which the condensation is made affect the character of the final condensate. It has already been noted that the charcoal process gasoline is condensed from a vapor-gas system under atmospheric pressure. This is in direct contrast to the methods of condensation used in the compression or oil absorption processes, where the pressure generally ranges between 90 and 250 lb. When these gasolines are placed in storage or released from compression, evaporation begins to take place immediately and desirable fractions of the gaso-

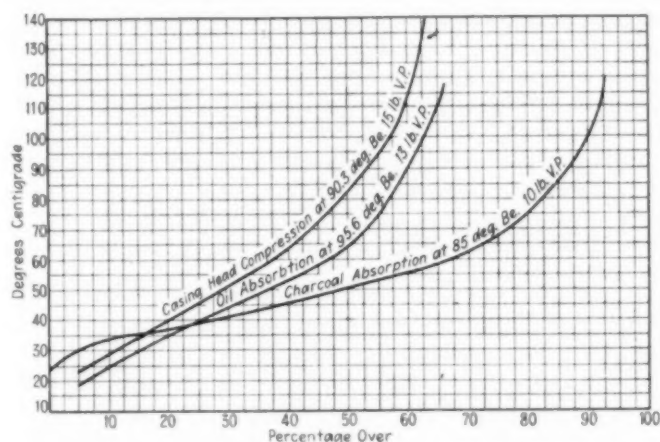


FIG. 6. COMPARISON OF GASOLINE PRODUCTS

line are carried away mechanically with the escaping undesirable wild vapors.

The method by which the condensation is carried on is also an important factor in determining the character of the condensate. The charcoal process is a batch process. Consecutive distillations of a series of absorbers are made rather than continuous distillations of a single still. This drives out the lighter vapors first and makes possible the addition of the blending naphtha to the fraction that actually needs blending. If there are any very volatile vapors left in the charcoal, they are driven out first by the lowest temperature and do not come into contact with the salable gasoline. By the oil absorption method, which is a continuous process, all fractions are driven out and carried to the compressors together. Here the salable vapors are condensed in the presence of the very volatile vapors under pressure, so that all the salable liquid must be saturated with wild vapors at the temperature and pressure used.

A third explanation for the better quality is found in the method of absorption itself. We have already mentioned selective absorption, which gives clear-cut fractionation controlled by the operator. The wild vapors are practically all re-evaporated into the gas within the absorber itself, thus preventing their presence in the steam-distilled vapors and condensate later on.

Experience has shown that the product from charcoal absorption plants has 3 lb. less vapor tension and 10 deg. less gravity than gasoline made by an oil absorption plant operating on the same gas.

Referring to Fig. 6, we see the results of applying the standard Bureau of Mines distillation test to the gaso-

line produced by the different methods. The initial boiling point of both compression and oil absorption gasoline is from 5 to 10 deg. below the initial boiling point of the charcoal gasoline. The final boiling points and the residue are practically the same. The curves of these distillations show that the big gain in yield is in the recovery of that product boiling between 30 and 70 deg. C., or within the range of the pentanes and hexanes. About 73 per cent of the charcoal absorption gasoline is within this class. Approximately 33 per cent of the compression and 38 per cent of the oil absorption are condensed between these temperatures.

The same series of tests showed that 93 per cent of the charcoal absorption gasoline is recondensed after

TABLE II. WEATHERING TESTS

I—First Pair. Air Temperature 65 Deg. F.									
Time in hours.....	0	1	2	4	5	18	22		
Oil absorption.....	1,000	995	970	950	940	856	850		
Charcoal absorption.....	1,000	1,000	998	993	990	930	925		
II—Second Pair. Air Temperature 65 Deg. F.									
Time in hours.....	0	1	2	4	5	18	22		
Oil absorption.....	1,000	994	968	950	938	854	847		
Charcoal absorption.....	1,000	1,000	998	994	990	930	927		
III—Third Pair. Air Temperature 80 Deg. F.									
Time in hours.....	0	2	3	4	5	9	22	25	
Oil absorption.....	1,000	965	945	935	922	890	830	828	
Charcoal absorption.....	1,000	995	988	982	977	960	900	898	

the standard Bureau of Mines distillation and approximately 66 per cent of the oil absorption and 63 per cent of the compression material were recovered. None of these samples had been blended before they were tested. The oil absorption sample had been made under a final pressure of 90 lb.

Fig. 7 is a curve showing the application of the Bureau of Mines distillation test to three different fractions of charcoal absorption gasoline. This brings out the fact that the fractionation was very sharp and even the first cut was quite staple.

The weathering losses of gasoline made by the charcoal process are very light. Table II shows three pairs of weathering tests, comparing samples of gasoline taken directly from the blender of a charcoal plant and

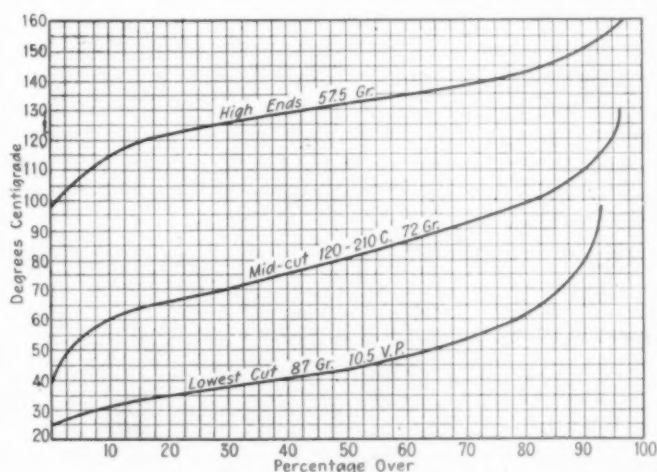


FIG. 7. CHARCOAL ABSORPTION GASOLINE CUTS

gasoline taken from the storage tanks of an oil absorption plant, where it has been allowed to weather under about 3 lb. pressure for more than two weeks. All samples were blended with 12½ per cent naphtha 56 deg. Bé. Each pair was kept under the same atmospheric and temperature conditions.

After what has been said about quality, the reader

may infer that the yield is being sacrificed. Such is not the case. A direct comparison between an oil plant and a charcoal plant operating on very lean gas showed that the oil plant averaged around 125 gal. per million cu.ft. of gas and had a weathering loss of 20 to 30 gal. before shipment. The charcoal plant produced an average of 203 gal. of high quality gasoline from this same gas on the same days. The reasons for this wide variation between the two plants are numerous. The problem of bringing every particle of gas into intimate contact with oil capable of absorbing the commercial vapors has always been difficult. Many kinds of baffles and sprays have been tried with varying degrees of success. With an absorber packed with from 8- to 14-mesh charcoal there is no difficulty in getting proper contact for complete extraction.

The absorption of the vapors by a solid medium is governed by conditions entirely different from those governing the absorption by a liquid which depends on reduction of molecular area of the dissolved vapor. It is the capillaries of the charcoal which alter the vapor tension of the absorbed paraffine and make the absorption possible. The degree to which the capillaries are deepened and oxidized free from interfering compounds determines the absorptive capacity of any particular charcoal. However, difference in grades of carbon or any other substance which might be used for the framework of these capillaries is an important factor which must not be overlooked when studying the conditions governing the absorption of gasoline.

The absorption process is actually a modification of the compression process, which consists of concentrating the recoverable vapors before applying the compression. But by the compression method it is possible to condense only a certain part of each fraction included in the gas. This part is determined by the number of fractions present, by the percentage of the different fractions present and by the temperature and pressure employed. It is only a specific application of the partial pressure laws. The addition of air or any gas not condensable at the working pressures means loss in efficiency.

PLANT

Suitable apparatus to practice the charcoal absorption process will include three essential units—viz., a power unit consisting of a boiler equipped with a superheater, an absorber unit consisting of at least three absorbers or charcoal containers, and a condenser unit consisting of cooling coils and a separation and blending tank.

Gasoline Recovery Corp.,
New York City.

Bureau of Standards Has New Standard Samples of Steel and Bronze

A new standard sample of electric steel No. 51, 1.2 per cent carbon, and a new standard sample of cast bronze No. 52 (approximate composition, copper 88 per cent, tin 8 per cent, zinc 2 per cent, lead 1.5 per cent, antimony 0.15 per cent, iron 0.10 per cent and nickel 0.10 per cent) have recently been prepared by the Bureau of Standards and are now ready for distribution with provisional certificates.

Standard sample No. 23a, a renewal of the exhausted sample No. 23, bessemer steel, 0.8 carbon, has also been prepared and is now ready for distribution with a provisional certificate.

The Conversion of Sawdust Into Cattle Feed

By E. C. SHERRARD*

RECENT investigations carried out at the Forest Products Laboratory indicate that the sawdust of coniferous woods can be converted into a wholesome cattle feed.

The process for preparing such cattle feed depends upon the conversion of part of the wood into sugar by cooking it for about fifteen minutes with a dilute acid under 120 lb. pressure. In this treatment about 20 per cent of the wood is converted into sugar and the remainder rendered more digestible. The sugars are then extracted from the digested dust with hot water, the acid is removed from the resulting solution by neutralization, and the liquor is evaporated under reduced pressure to a thick sirup. The concentrated sugar solution thus obtained is then mixed with the residue left after cooking and the whole is dried to less than 15 per cent moisture content. The finished material is darker than the original sawdust, is very brittle, and contains a larger proportion of fine dust.

FAVORABLE RESULTS AT PRELIMINARY FEEDING TRIAL

A preliminary feeding trial, using a product prepared in this way from Eastern white pine, was conducted by the Wisconsin College of Agriculture with favorable results. Three cows were fed by the reversal method for three periods of four weeks each. In the first and third periods they were given an excellent ration, consisting of alfalfa hay, corn silage and a concentrate mixture of 55 parts of ground barley, 30 parts of wheat bran and 15 parts of linseed meal. In the second period hydrolized sawdust was substituted for part of the barley, 2 lb. of sawdust being fed in place of each pound of barley, as it was not expected that hydrolized sawdust would have as high a feeding value, pound for pound, as barley. The mixture used during the second period contained about 26 per cent of hydrolized sawdust. At no time was any difficulty experienced in getting the cows to clean up this concentrate mixture. The cows maintained their production of milk in the second period as well as in the first and third and showed an appreciable increase in butter fat production. A decided increase in weight was noted during the period in which they were fed the treated sawdust.

NO DEFINITE CONCLUSION YET

While no definite conclusions can be reached from this brief trial, the results do show that cattle may be fed a limited amount of hydrolized sawdust with beneficial results. It should be pointed out that hydrolized sawdust contains only a negligible amount of protein and that it must necessarily be fed in conjunction with other nitrogen-containing materials. In both rations used in this trial plenty of protein was furnished by the other feeds used.

We wish to emphasize the fact that these experiments are preliminary and that as yet the laboratory is not in position to advise as to the commercial application of the process. Further trials will be carried out to furnish additional data on the feeding value and methods of preparation.

Madison, Wis.

*Chemist in Forest Products, Forest Service, U. S. Department of Agriculture.

Steel Castings of High Strength and Toughness—II

A Chapter From a Forthcoming Book Giving Data on the Improvement to Be Expected After Properly Heat-Treating Steel Castings, With Illustrative Tests on Strong, Tough Castings Which Have Replaced Forgings on Gun Mounts

BY FEDERICO GIOLITTI
Bessemer Medalist

IT WOULD be easy to record a great number of other examples similar to the ones mentioned in the first part of this chapter¹ and illustrates still better the results which may be obtained on steel castings by means of rational normalizing.

Those steel castings already described in an earlier portion of the book would be especially interesting. In these the correct selection of the steel's composition, the special precautions taken during the melting and pouring operations, and the rational application of homogeneity and final heat-treatments would procure articles whose metal would possess physical properties fully comparable to those of the best forged and treated steels.

This is especially interesting in showing how suitably manufactured castings, subjected to a rational heat-treatment, may be substituted in many cases and with great advantage—especially as far as rapidity of manufacture is concerned—for pieces of steel which formerly were necessarily forged and heat-treated. Forged pieces naturally require very tedious and expensive machining operations, in order to be brought to the final form, which in good casting practice is almost entirely obtained by the molding.

Even before 1915 a great deal of study was given to the fabrication and heat-treatment of high strength special steel castings at the steel works of Gio. Ansaldo & Co., obtaining results so satisfactory as to permit castings being used for a great number of gun-carriage

and gunmount parts and of machine parts which had heretofore been fabricated exclusively by tedious machining from heat-treated forgings. The use of these special castings allowed that firm largely to increase its production, and the practice has therefore been greatly extended. Experience with several thousand gun carriages under the severe and exacting use demanded during three years of the great war has fully confirmed the practical advantage and the reliability inherent in the substitution of heat-treated special steel



FIG. 24. MICROSTRUCTURE OF UNTREATED NICKEL STEEL CASTING. $\times 80$

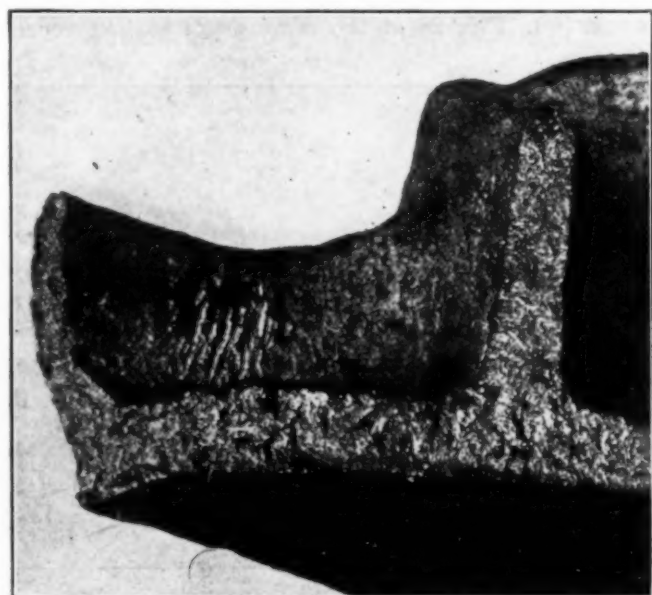


FIG. 23. FRACTURE OF UNTREATED NICKEL STEEL CASTING

castings for steel forgings. This substitution can fortunately be done in a great number of cases where the intensity and nature of the forces to which the mechanical parts must be subjected in service were such as to establish the conviction, held even by the Ansaldo company until a comparatively short time ago, that such substitution was practically impossible.

It is from among these very cases that the following examples will be selected.

CHARACTERISTICS OF MEDIUM HARD NICKEL STEELS

The steels used in the Ansaldo works for the manufacture of such castings are made in the acid open hearth, and the practice has been studied essentially with the end in view of obtaining perfect "deoxidation" of the metal, and the highest possible elimination of "emulsified" non-metallic inclusions which possess an oxidizing power upon the mass of the steel. Another characteristic of the steels in question, due in part to the specific action of the titanium and vanadium used

¹For Part I see CHEM. & MET. ENG., vol. 24, No. 3, Jan. 19, 1921, p. 113.

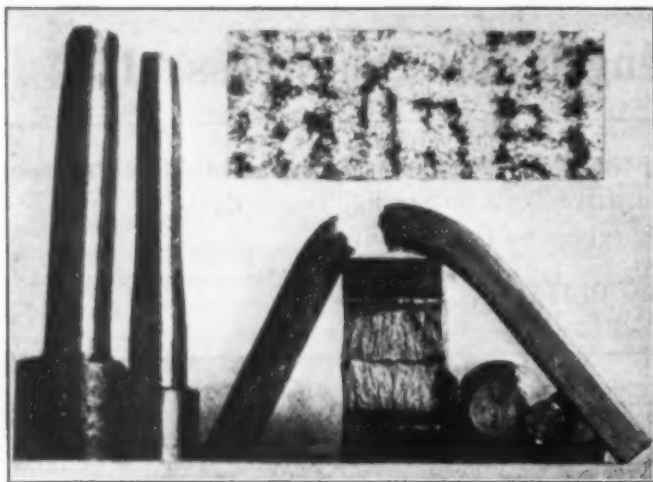


FIG. 25. TESTS ON ANNEALED NICKEL STEEL CASTING

in their manufacture, is the great "frequency" of the centers of alpha crystallization which form in austenite during allotropic transformation. The great practical importance of this fact has already been set forth by numerous examples, illustrating how the potency and reliability of the heat-treatments are affected.

The steels we are now concerned with belong to the group of the medium hard nickel steels. They are quite brittle when cast and tested prior to any heat-treatment—in fact, averaging the following physical properties:

Tensile strength.....	71,100 to 76,800
Elastic limit.....	54,000 to 61,200
Elongation, per cent.....	3 to 5
Reduction of area, per cent.....	2 to 4
Charpy impact test, kg.-m. per sq.cm.....	1 to 2

A flexure test-piece breaks before even slight bending. The coarsely crystalline structure, typical of these steels as cast, appears still better developed upon the fractured surfaces obtained by bending untreated castings of medium or large dimensions in a press. A typical example of such structures is reproduced in Fig. 23. Fig. 24 shows the normal microstructure of these cast steels before any heat-treatment.

Even simple reheating followed by slow cooling remarkably improves the properties of these steels. Thus, annealing for about three hours at 850 deg. C. imparts variable physical properties within the follow-

ing limits depending upon the composition of the steel and the dimensions of the castings:

Tensile strength.....	71,100 to 78,200
Elastic limit.....	54,000 to 61,200
Elongation, per cent.....	15 to 22
Reduction of area, per cent.....	25 to 35
Impact tensile strength, kg.-m.....	80 to 110
Impact elongation, per cent.....	18 to 27
Transverse impact (Charpy test), kg.-m. per sq.cm.....	4 to 6

A beam subjected to gradual loading usually breaks at an angle of about 90 to 110 deg., as shown in Fig. 25, which also reproduces the appearance of the other fractures. The broken surfaces still show evident traces of the dendrites. Microstructure of the annealed steel is generally as shown (enlargement 60 diameters).

Mild homogeneity heat-treatments such as those studied in the previous chapters modify the structure, which we have often noted as that normal for hypoeutectoid steels of medium carbon content. For instance, annealing followed by rapid cooling in air causes a microstructure of the type reproduced in Fig. 26. A

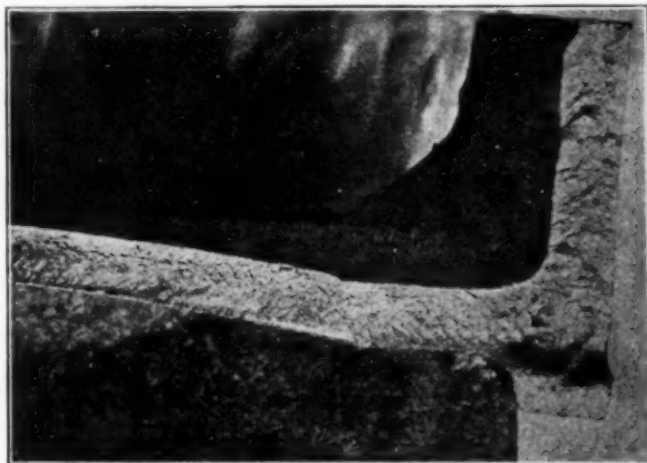
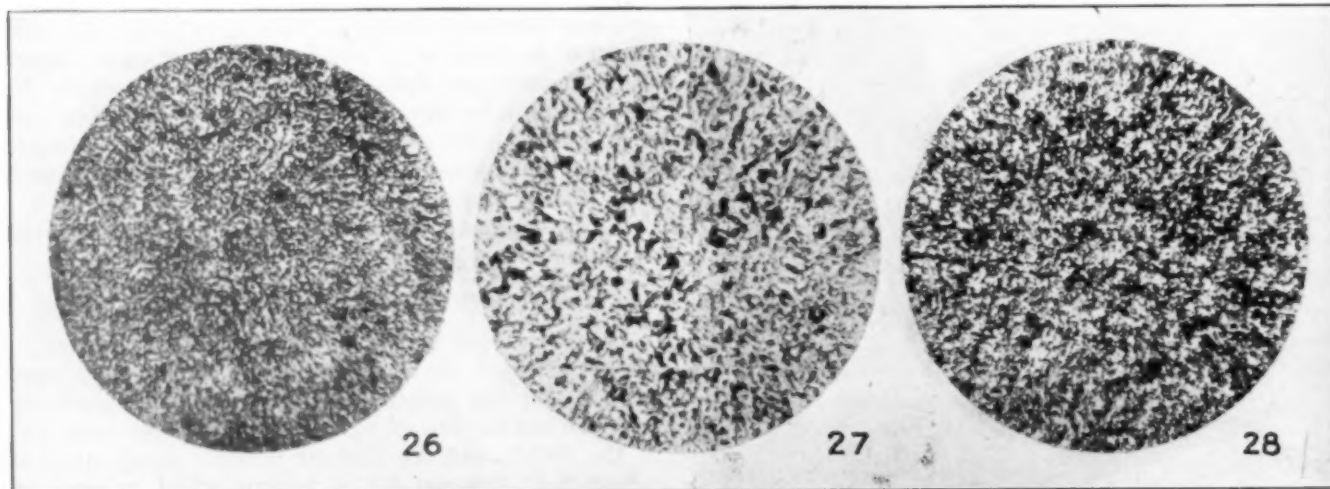


FIG. 29. FRACTURE OF HEAT-TREATED SPECIAL STEEL CASTING

drawing operation following such an air quenching will give rise to the structure reproduced in Fig. 27. The slight ferrite segregation is entirely normal. As a comparison, Fig. 28 at the same magnification repro-



FIGS. 26 TO 28

Fig. 26. Annealed, air-quenched

Fig. 27. Same as Fig. 26, then drawn

Fig. 28. Air-quenched after forging



FIG. 30. YOKE BEFORE TESTING

duces the structure of the same steel as the one shown in Fig. 27, when quenched in air *after forging*. Evidently the difference between the two microstructures is not remarkable.

APPLICATION OF MULTIPLE HEAT-TREATMENTS

We have previously noted the reasons why a *simple* homogeneity heat-treatment consisting of a single annealing or quenching, even if followed by drawing, does not give results so good as those which can be obtained by more complex treatments. Without going over arguments already discussed at sufficient length, I will only recall that this depends upon the fact that the conditions under which the various phases of a complex treatment take place may be so selected that each of them may develop one of the desired characters up to a certain point without introducing dangerous defects which may eventually accompany the development of that desired property to its maximum. In general such a criterion may be applied only under condition that the successive phases of a complex treatment may be conducted in such a way as to eliminate, or at least sufficiently attenuate, such dangerous effects as may take place in the previous phase.

We have seen numerous examples. Here it is sufficient to remember that even though a preliminary annealing or quenching attended by a very prolonged reheating at a high temperature may give special steels of the type now under consideration a very remarkable homogeneity of chemical composition in the austenitic state, yet on the other hand such practice favors grain growth. Then if the metal has to undergo a slow cooling in the



FIG. 31. YOKE IMMEDIATELY AFTER FRACTURE

successive phases of the treatment, it may easily show Widmanstätten structure, more or less well developed. This case is only another example added to those we have already seen, that the advantages of great uniformity in concentration obtained by means of very energetic homogeneity annealings or quenchings cannot be conveniently exploited in industry, except under condition that further phases of the treatment may eliminate the serious injury which always accompanies the above-mentioned advantages in larger or smaller measure.

It has already been pointed out that in practice the steel may be restored by means of hot work and also by means of certain heat-treatments, consisting essentially of quenchings from relatively low temperatures—such as from within the transformation interval—properly conducted in such a way as to graduate their intensity.

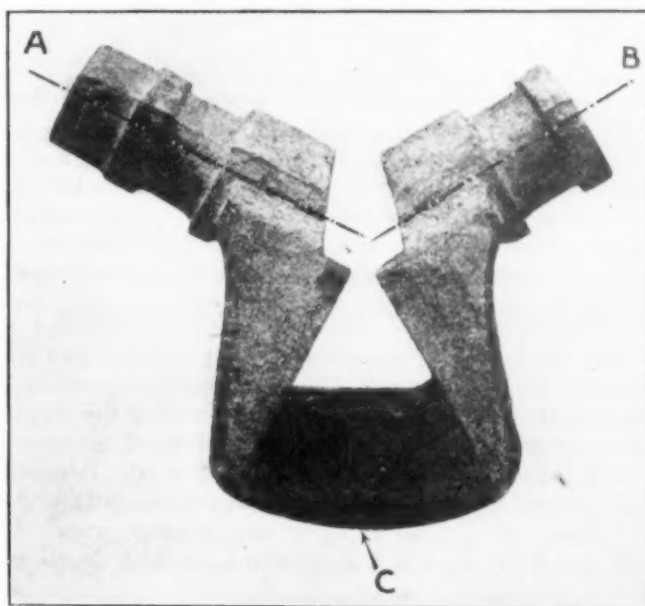


FIG. 32. TRUNNION AFTER BENDING

In these very cases mild quenching as in air, lead, hot oil, boiling water, etc., present the highest practical interest. They permit one to adjust the quenching effect at any desired intensity in the series, starting from the energetic quenchings and ending with quenchings so prolonged as to be comparable to actual annealings. It has already been noted that the special steels lend themselves most favorably to the application of these processes. A correct selection of chemical composition permits a large variation in several different properties: the normal location of $\gamma \rightarrow \alpha$ transformation temperatures, the metastable lowering of these limits, the extreme temperatures of said interval, and, finally, the amount of thermal hysteresis.

Selection of steels possessing strong thermal hysteresis, relatively low transformation points and closely packed centers of ferrite crystallization obviates the necessity of sudden quenchings to preserve the homogeneity obtained at the high temperatures reached in one or more of the phases of the heat-treatment. The main practical consequence of this fact is that the complex heat-treatments may be efficaciously applied to castings of large dimensions and intricate form as well as to simple thin pieces, imparting uniform physical properties to all their parts, even those of varying thickness. Moreover, the application of the desired

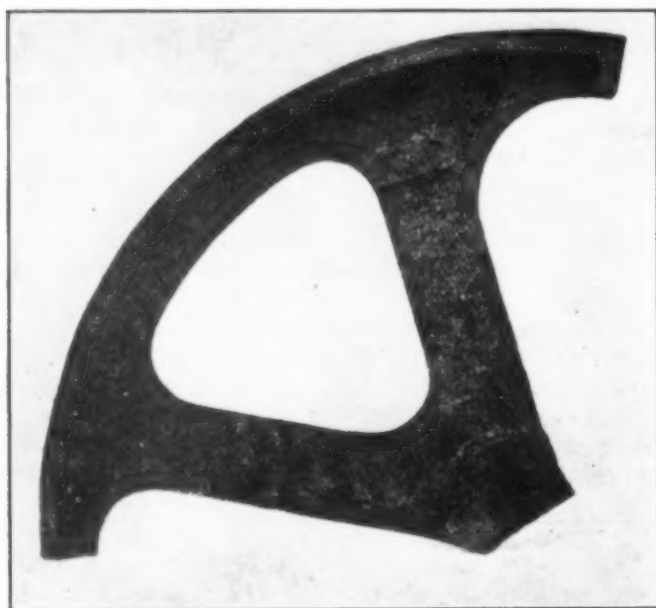


FIG. 33. ORIGINAL CONDITION OF SECTOR

heat-treatments is safer because the elimination of quenching avoids the formation of chance quenching cracks. In the great majority of cases the velocities of cooling obtainable with simple air-chilling is sufficient.

EXCEPTIONAL PHYSICAL PROPERTIES OBTAINED

The physical properties which may be obtained by applying the more complete heat-treatments to the cast special steels under discussion range within the limits given below, according to the composition of the metal and to the dimensions of the castings treated. Bending tests under gradual load always reach the maximum deformation into a "U" without showing any crack. If bent flat upon itself it will develop a perfectly localized break.

All fractures have a finely fibrous structure. An illustrative casting when broken by bending under a press presents uniform fibrous fractures from which every trace of crystalline structure has totally dis-



FIG. 34. SECTOR AFTER TWISTING

appeared. For instance, Fig. 29 clearly shows the characteristic dullness or lack of luster and lacerations proper to the broken surfaces of tough metals.

Tensile strength.....	92,500 to 120,900
Elastic limit.....	56,900 to 106,700
Elongation, per cent.....	15 to 30
Reduction of area, per cent.....	40 to 65
Resistance to impact (Charpy test), kg.-m. per sq.cm.....	9 to 15
Impact tensile strength, kg.-m.....	115 to 145
Impact elongation, per cent.....	25 to 35

Even in harder casting the property of withstanding great deformations when cold before breaking is also

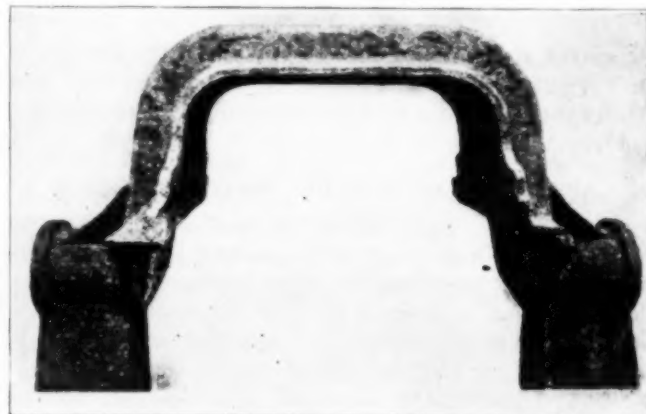


FIG. 35. ORIGINAL CONDITION OF TRUNNION

associated with great toughness, as appears from the above physical properties. I would like to emphasize the fact that the castings which I shall now describe were all of high tensile strength steel, in which the tenacity was always above 110,000 lb. per sq.in. and the elastic limit above 70,000 lb. per sq.in. This remark is of the utmost importance properly to appraise the deformations to be described—deformations which could easily be obtained even after simple annealing with mild steel castings whose elastic limit would not be far

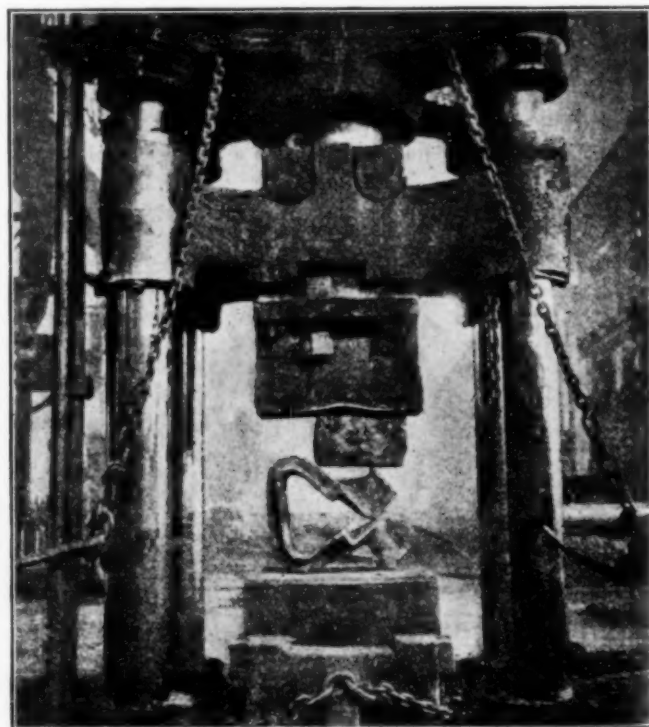


FIG. 36. TRUNNION UNDER TEST



FIG. 37. TURNING FROM A HARD CASTING

from 42,000 to 50,000 lb. per sq.in., but which represent exceptional results for hard, high-strength steels possessing the physical properties comparable only to those which can be obtained with forged and heat-treated steels.

A first example is furnished by the piece shown in Fig. 30. A load of 16½ tons was applied by hydraulic press at the ends of the casting while the central boss rested on a single central support. After bending so that the lugs at the ends were lower than the central support not the least crack was found in the piece. On increasing the pressure the piece broke partly through in the manner shown in Fig. 31. Complete fracture was obtained only when the ends were pressed together in actual contact.

A cast trunnion made of high strength heat-treated steel was deformed by pressing against the two ends so as to squeeze them together in the way indicated in Fig. 32. Line AB was originally straight. During this test high external ribs on the under side at C did not develop the least crack, although they were badly stretched.

The sector illustrated in Fig. 33 was placed in a press so that the two points of the arch were squeezed together until it was deformed as shown in Fig. 34. The metal's exceptional toughness in spite of its hardness is demonstrated especially by the absence of fractures even at places where large difference of thickness occur, and where the lines of deformation "accumulated."

Finally, another large trunnion of the same kind of steel and manufactured in the same way is illustrated in Fig. 35 as it appears before cutting the two risers. It was also loaded by a hydraulic press so as to push the ends toward each other. Having reached a condition where the risers were in contact, they were sawed off and the trunnion again placed under the press, as shown in Fig. 36. Localizing the pressure upon the trunnions by means of a block of steel, placed between the hammer and the upper trunnion as shown in the figure, the bending was continued to the point shown without causing the smallest crack in the piece.

In closing these observations regarding castings of heat-treated special steel, it may be mentioned that even during machining such castings present characters of toughness and plasticity which equal and even exceed

those of very mild steel castings or those of the best forged and heat-treated steels. As an example apt to illustrate this fact, I reproduce in Fig. 37 at about one-sixth natural size the appearance of a turning cut from one of the hard castings in question. The figure needs no comment.

Wood-Preserving Industry in 1919

The following statistics on the wood-preserving industry during 1919 are given in a recent Forest Service bulletin issued by the Department of Agriculture:

In 1919 there were 65,556,247 gal. of creosote, 2,412,592 gal. of paving oil, 102,011 gal. of miscellaneous preservatives used in the United States, in addition to 43,483,000 lb. of zinc chloride, the largest quantity of this preservative ever reported by the industry. Of the creosote, 6,493,000 gal. was imported.

Prior to 1917 the plants of this country depended upon foreign manufacturers for approximately 50 per cent of the creosote consumed. Most of this oil came from Germany and England. During the war, however, this supply was cut off, and the plants looked to domestic producers for their supply. Nearly all of the importations in 1919 were from England and Canada.

The material treated consisted of cross-ties, poles, wood blocks, crossarms, construction timbers and miscellaneous material, largely for railroads, mines and telegraph and telephone companies. The total amount of wood subjected to preservative treatment by the 108 plants that were active during 1919 was 139,878,584 cu.ft., or 17,265,694 more than the previous year. About 80 per cent of this wood consisted of railroad cross-ties.

Comparison of Five Different Types of Glue*

For the convenience of those who use glue in wood-working, the Forest Products Laboratory has prepared the following tabular summary of the chief characteristics of five types of glue:

Particular Compared	Animal Glue	Casein Glue	Vegetable Glue	Blood Glue	Liquid Glue
Source	Hides, bones, horns, etc.	Casein from milk	Cassava starch	Dried blood	Animal glue or fish parts
Cost per lb. 1920	25-42 cents	16-20 cents	10-12 cents	20 cents	\$1-\$5 per gal.
Spread in sq. ft. per lb.	25-35	35-55	35-50	30-100	No data
How mixed	Soaked in water and melted	Mixed cold with rapid stirring	Mixed with alkali and cold or hot water	Mixed cold	No preparation
How applied	Warm with brush or mechanical spreader	Cold with brush or mechanical spreader	Cold with mechanical spreader, not by hand	Cold with brush or mechanical spreader	Cold or warm usually applied by hand
Temperature of press	Cold or with hot cauls	Cold	Cold	Hot	Cold
Strength (in shear test)	High grades stronger than strongest woods	Equal to medium grade animal glue	Equal to medium grade animal glue	High strength in plywood Not used for joint work	Best grades equal to medium grade animal glue
Water resistance	Low	High	Low	High	Low
Chief uses in wood-working	For strong joint work	For water resistant plywood or joint work	For veneer work because of cheapness	For water resistant veneers	For repair work and small articles

* From Technical Notes, Forest Products Laboratory.

Abnormal Behavior of a Weston Standard Cell

BY M. G. MELLON

EXPERIMENTAL work has shown that the Weston standard cell furnishes, in general, a very accurate and satisfactory standard of electromotive force, in having a ready reproducibility, a small temperature coefficient and an electromotive force whose value is suitable for most requirements. Generally these cells are very constant, Hulett and Lipscomb¹ having reported recently the use of certain Weston cells over a period of twelve years. Also most of these cells do not show the disturbing phenomenon of hysteresis. Occasionally however, there is encountered a cell which has not maintained the desired constancy, or one which does not show the expected change of electromotive force with corresponding change of temperature—that is, it exhibits hysteresis.

VARIATIONS SHOWN BY ONE CELL

In some recent work a Weston cell was found to have an abnormally low electromotive force, and to show hysteresis. These variations from the expected results are not new observations. The object of the present note is merely to call attention to them again, because of the belief that some, using such standards, may be inclined to put equal dependence upon the reliability of all Weston standard cells, especially since some reputable dealers advertise that these cells' "accuracy and trustworthiness are beyond question, and with careful handling will remain so for many years."

The Weston cell mentioned was of the unsaturated type and was purchased from the Weston Electrical Instrument Co. in 1917. It was certified at the Weston Laboratory on May 1, 1917, as having an electromotive force of 1.01850 international volts at 25 deg. C., and a temperature coefficient of less than 0.00001 volt per degree C.

CONDITIONS UNDER WHICH TESTS WERE MADE

This cell had been used very little, and never as a working standard, its actual use being a reference cell with which to compare other Weston cells employed through a long series of measurements. In 1917 only a few such comparisons were made, and at that time this cell showed its certified value. No more measurements were made with it until about March, 1919. In the meantime it had been kept in a good apparatus case at the ordinary temperature of the chemical laboratory, and had been subjected to no misuse. At the time of the comparisons in 1919, it no longer agreed with two other closely agreeing, although considerably older, similar Weston cells. Different results were obtained on different days, at approximately the same temperatures; and the values were always at least one millivolt below the certified value.

Accordingly, the cell was sent to the Bureau of Standards for an official test, and the following report was issued for it:

TEST OF UNSATURATED WESTON STANDARD CELL 3,539

The cell was maintained throughout the period of observation within a well insulated box to protect it from abrupt changes in room temperature. The electromotive force in international volts is given by adding the difference in hundred-thousandths of a volt,

tabulated below, to 1.01830 volts, the value adopted by international agreement for the Weston normal cell at 20 deg. C.

DIFFERENCES, HUNDRED-THOUSANDTHS OF A VOLT, FROM 1.01830

Date	International Volts Temperature Deg. C.	Differences	E.M.F.*
April 11	25.0	—116	1.01714
April 12	24.8	—111	1.01719
April 14	23.9	—102	1.01728
April 15	24.5	—123	1.01707
April 16	24.5	—122	1.01708
April 17	24.8	—126	1.01704
April 18	24.4	—117	1.01713
April 21	23.9	—121	1.01709
April 22	24.0	—112	1.01718

*This column was calculated and was not included in the original report.

Because of the abnormal value and of the large amount of hysteresis exhibited with relatively small (and necessarily slow) changes in temperature, we cannot issue our usual certificate certifying this cell to an accuracy of 0.01 per cent.

A marked contrast with the above results was observed in the case of a second, similar cell. This one, purchased in 1915, and certified Oct. 15, 1915, as having an electromotive force of 1.01865 volts at 25 deg., was used at the working standard through three extended series of measurements, the first in 1916, the second in 1917 and the third in 1919. During the last series the cell's electromotive force was practically the same as when first certified.

CONCLUSIONS

The phenomenon of hysteresis described above is not a recent observation in connection with Weston cells, as shown by the work of Dearlove,² Barnes,³ Barnes and Lucas,⁴ and Wolff.⁵ One of the main points to be kept in mind seems to be the uncertainty of knowing which cells may be expected to show such results. After measuring about two hundred cells, Wolff states, as part of his conclusions,

1. That Weston cells can be set up which exhibit extremely little hysteresis in the range 0 to 40, even when subjected to large and rapid temperature variations.

2. That some of the cells showed marked and persistent hysteresis, particularly at lower temperatures.

3. That a similar behavior was found in most of the cells having abnormal values at room temperatures.

The conclusions to be drawn from this note are:

1. The necessity of keeping in mind the fact that all Weston cells do not remain constant over an indefinite time, even though used very little.

2. The advisability of standardizing carefully any Weston cell before employing it for accurate measurements.

3. The probability of obtaining uncertain results using any cell showing such a marked hysteresis, unless its temperature is maintained rigidly constant, as in a carefully regulated thermostat.

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Shipments of German Potash

According to figures furnished by the German Potash Syndicate, the sales of potash salts in 1919 reached a total of 4,159,227 metric tons with 812,002 tons of potash. In 1918 the sales amounted to 4,840,934 tons of potash salts with 1,001,664 tons of potash.

¹Dearlove, *Electrician*, vol. 31, p. 645 (1893).

²Barnes, *J. Phys. Chem.*, vol. 4, p. 339 (1900).

³Barnes and Lucas, *Ibid.*, vol. 8, p. 196 (1904).

⁴Wolff, *Trans. Am. Electrochem. Soc.*, vol. 13, p. 187 (1908).

The Rise and Development of the Electrolytic Alkali and Chlorine Industry in Europe—III

An Outline of the Electrolytic Cells Employed in the Electrolytic Alkali and Chlorine Industry of the United Kingdom, Germany, Austria, France, Italy, Switzerland, Russia and Belgium*

By JOHN B. C. KERSHAW

Electrolytic Alkali and Chlorine Industry in France

THE war caused a great increase in the number and capacity of the works for the decomposition of brine by electrolysis in France, since the necessity for producing liquid chlorine on a large scale for the use of the army authorities compelled the extension of many existing electrolytic plants and the erection of some new ones.

According to reliable figures published last year in *La Revue des Produits Chimiques* there were nine works producing liquid chlorine by the electrolytic method in France in 1917, and the aggregate capacity of these plants was 73 tons of gas (or the equivalent of 125 tons of salt decomposed) per twenty-four hours. Only two works were engaged in the electrolytic alkali and chlorine industry in 1914, and this rapid expansion was rendered possible only by the large number of electrochemical and electrometallurgical works which had been established in the Rhone Valley and in the Haute Savoie and French Alps before the war. The water power of this district of southeastern France had in fact been largely exploited in the period 1890-1910; and luckily for France this district of the country was far removed from the zone of actual hostilities and thus escaped the devastation which laid waste the coal-mining districts of the north. Had the Germans managed to penetrate the Rhone Valley, not many of the hydroelectric plants would have escaped destruction.

The number of different cells and processes utilized in these nine electrolytic works are four—namely, the Griesheim-Elektron at Lomotte-Breuil; the Outhenin-Chalandre at Pomblières St. Marcel, Jarrie, Paimboeuf and Mansieux; the Solvay mercury cell at Saint-Aubans; and a cell and process patented by the Soc. pour l'Industrie Chimique à Bâle, at Montereau, Pont de Claix, Peage de Rousillon and Plan du Var.

The Griesheim Elektron and Solvay mercury cells have been already described; and it is only necessary to describe here the Outhenin-Chalandre and Bâle cells.

THE OUTHENIN-CHALANDRE CELL

This cell was patented in 1893 by the Soc. Outhenin-Chalandre Fils & Cie. of Paris, but it has never been operated in the United Kingdom or America, and its use is confined to France and Switzerland. One-third of the liquid chlorine produced in France during the war period was obtained from this type of cell.

The cell is of the diaphragm type, but differs from those previously described in the fact that the diaphragms are constructed in the form of tubes and are arranged in tiers almost horizontally under the bell-shaped hood, which contains the anodes and serves

to collect the liberated chlorine gas. Fig. 16 shows vertical sections of the cell, which is seen to be quite complicated in design and character. *A* represents the main conductor attachment for the anodes, and *M* that for the cathodes.

Flat carbon anodes (*aaa*), extend between the diaphragm tubes, as shown by the dotted lines, into the brine contained in the closed anode chamber of the cell; and the current is led away from the interior of the diaphragm tubes (*ccc*) by projecting lugs of the iron cathode bar *M*; these lugs (*mmm*) extend along the interior of the tubes and serve as the disengagement surface for the hydrogen gas. The caustic

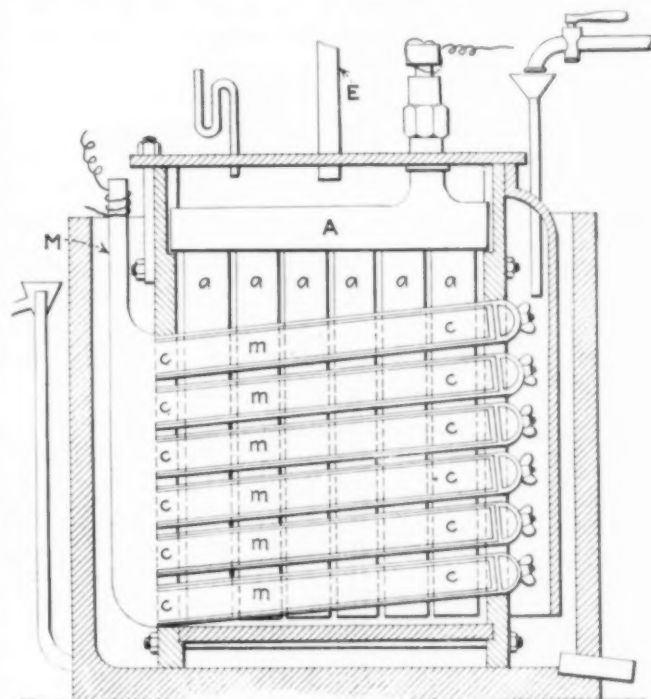


FIG. 16. THE OUTHENIN-CHALANDRE CELL

soda solution which forms on the surface of these cathodes flows by gravity down the interior of the inclined tubes and collects at the bottom of the outer cell, while the chlorine gas is led away from the closed anode chamber or bell by the exit pipe *E*.

The works at Pomblières Saint Marcel was started in 1899 by the Société la Volta and was the first operated in France for the electrolytic decomposition of brine. In 1915 it was acquired by the Société d'Electrochimie et d'Electro-Metallurgie of Paris and was greatly extended in order to produce liquid chlorine for war purposes. In 1917 it was producing ten tons of liquid chlorine per day.

The company which now owns this works was origi-

*For Parts I and II see *CHEMICAL & METALLURGICAL ENGINEERING*, vol. 24, Nos. 2 and 3, pp. 77 and 119.

nally promoted by Gall & Montlaur for the production of electrolytic chlorates at Vallorbes, in Switzerland, with a small water power of 3,000 hp. It has gradually extended its operations until it is now the largest electrochemical and electrometallurgical company in France, controlling over 50,000 kw. of generating plants situated at the following places: St. Michel de Maurienne; St. Avre la Chambre; N. D. de Briançon; Pomblières St. Marcel; St. Jeoire en Faucigny; Les Clavaux; Pierre Benite; La Barasse; Viellers St. Sepulcre; Vallorbe, and Martigny-Bourg; the last three places in the list being in Switzerland.

THE BASEL TYPE OF CELL

The process and cell of the Soc. pour l'Industrie Chimique a Bâle has been introduced into France during the war, and in 1917 this type of cell was producing nearly one-half of the total output in France (72 tons) of liquid chlorine per day of twenty-four hours. The cell in some respects resembles the Outhenin-Chalandre type of cell, but is rather less complicated in design and is also less costly in upkeep.

This cell is now employed in a large number of electrolytic works in France, Italy and Switzerland, and has been adopted recently by the Soc. Italiana di Elettrochimica of Rome, for its works at Bussi.

The cell is protected by British patent 11,872 of 1913. The following account is based partly on the British patent specifications and partly on a communi-

caustic hydrate formed at the same point and shall carry this hydrate to the surface of the electrolyte and thus remove it from the sphere of secondary chemical and electrolytic reactions.

For this purpose the cathode is placed within a comparatively narrow cathode chamber, constructed of a material permeable to brine, as for example, within a bag having roughly the same form as the cathode and made of a narrow-meshed asbestos fabric. The hydrogen eliminated in this relatively small cathode chamber produces on the surface of the electrolyte a froth consisting of bubbles of hydrogen, the shells of which con-

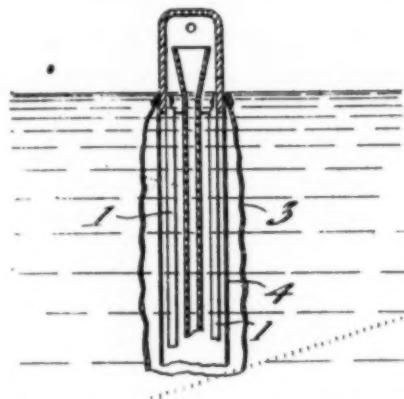


FIG. 18. MODIFIED FORM OF UPPER PART OF BASEL CELL CATHODE

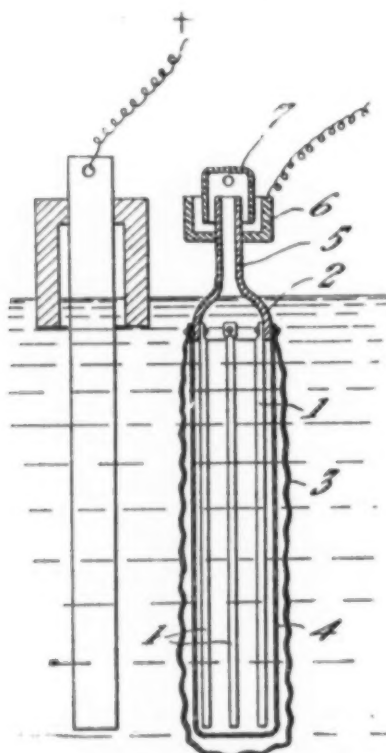


FIG. 17. GENERAL FEATURES OF THE BASEL CELL TUBE FORM OF CATHODE

cation from the Swiss company received recently by the writer. The chief distinctive feature is what its designers and patentees call a "propulsive cathode," which permits the attainment of a high current capacity in cells covering only a small area and produces at the same time a liquor containing a fairly high percentage of alkali.

The principle of this electrode is that the hydrogen gas evolved at its surface shall act as carrier for the

sist of solution of alkali carried up by the gas. In order to conduct away this froth the upper part of the cathode chamber is contracted so that froth rises in this contracted part and flows over into a suitable receiver in which the hydrogen separates from the cathode liquid that has been carried with it. The cathode may be of various forms, for instance, a rod, in which case the cathode chamber is most suitably formed as a tube; or a plate, in which case the cathode chamber has the form of a narrow box.

The portion of the cathode sheath, or bag, immersed in the electrolyte is permeable and is usually made of coarse asbestos cloth. The upper part, which projects above the electrolyte, is impermeable and is contracted into a narrow iron pipe which serves as conductor for the electric current and is coated with an insulating paint.

GENERAL FEATURES OF THE BASEL TYPE OF CELL

Fig. 17 from the patent specification shows the general features of the tube form of cathode in sectional elevation and indicates the method by which the asbestos sheath, or bag, is attached to the metal top (2). The line marked (4) represents a frame of wire-netting which is used to keep the asbestos cloth extended and also may serve as an extension of the cathode surface. The contracted portion or pipe (5) of the upper part (2) is fixed in a receiving gutter (6). This gutter may also act advantageously as a current conductor for a large number of individual cathode cells, since any desired number of such cells can be attached to it. Within the gutter there may be a hood (7) beneath which the hydrogen collects. It will be obvious that there are many ways of conducting away the cathode current and the hydrogen from the cell. For example, the pipe (5) may be curved over, so as to deliver the solution into a receiver arranged on one side; or as another example, the upper part of the cathode cell can

be formed as shown in Fig. 18. In this case, there extends through the cathode chamber a pipe widened at its upper end to form a funnel and the alkali solution flows down through this pipe.

When such a propulsive cathode, together with a carbon anode, is immersed in a solution of brine and an electric current is passed through it, the current operates in the following manner: In the interior, caustic soda and hydrogen are liberated. The latter carries, in rising through the liquid, the caustic soda solution upward. A froth is formed, consisting of hydrogen bubbles contained in shells of solution of alkali; this froth rises in the contracted iron tube (5) very quickly, and flows over at the top in a continual stream into the receiver (7), in which a separation into hydrogen gas and caustic soda solution at once takes place. The rising hydrogen bubbles and the continual

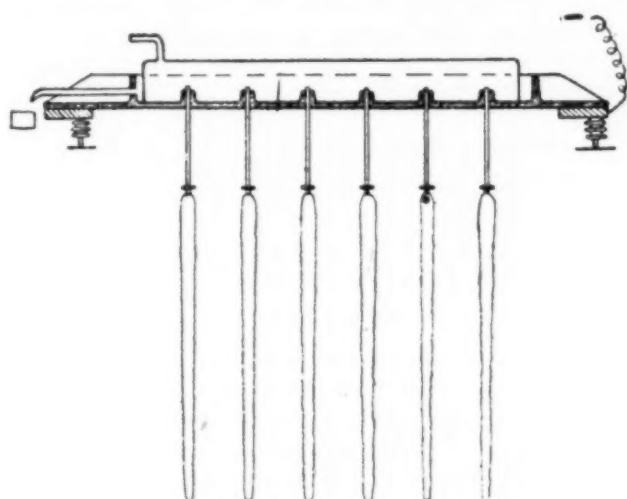


FIG. 19. BASEL CELL CATHODE UNIT

upward streaming of the electrolyzed liquid act on the brine outside with a strong suction, the result being that over the whole surface of the permeable casing of the cathode a continual stream of fresh electrolyte percolates into the interior, forcing the OH ions (which are usually a source of loss) constantly backward in the direction of the cathode. The rate of upward flow of the cathode liquid and the automatic percolation of fresh brine corresponds to the number of amperes with which the cathode is loaded at any moment. This load may fluctuate within fairly wide limits without having any influence on the efficiency of the cathode, and owing to the permeability of the asbestos bag, the voltage drop is low. As a rule only the resistance of the brine comes into account.

The propulsive cathodes are now manufactured on a large scale to a standard size. Any number can be screwed from below into an iron gutter, and one obtains in this manner the larger cathode unit, shown in Fig. 19. This gutter is fitted to a frame which serves as negative current conductor, and the electric current is carried by this gutter to all the cathodes of the cell. The gutter serves also as receiver for the alkali solution overflowing from each cathode tube. It is covered by a collecting hood for the hydrogen separating from the solution. Gutters and hoods are connected with collecting pipes for the alkali solution and the hydrogen respectively.

As a second component part of the Basel type of cell, in connection with the construction of larger electro-

lyzers, a new form of anode unit is being employed. This consists of a long narrow bell made of some non-conducting material, into which a number of carbon anodes are fixed. In order to obtain as small a distance as possible between the cathodes and the anodes, it has been found advantageous to fix to the bell a bag of the same texture as that employed for the cathodes. The bell has, of course, an opening at the top through which the chlorine rising from the anodes enters the collecting pipe line, by which it is conducted away.

Every electrolyzer is made up of a definite number of the anode and cathode units described above, according to the kw. capacity of the cell and yield of caustic soda and chlorine required. The anodes and cathodes are connected in parallel as shown in Fig. 20. The size of cell employed by the patentees in their own works at Basel produces about 190 kilos of chlorine per twenty-four hours, with the equivalent quantities of NaOH and hydrogen. An electrolyzer having this output requires a depth of rather more than 40 in., and a superficial area of 5 ft. by 10 ft. Usually thirty cells of this size are connected in series.

PRODUCT OF THE BASEL CELL

The concentration of the alkali liquor from the Basel cell varies from 11 to 13 per cent NaOH, or 15 to 17 per cent KOH. The liquor contains some undecomposed chloride, but the amount is not specified. The gas liberated at the anodes tests 98 per cent chlorine, and always less than 2 per cent carbon dioxide, with traces of oxygen. The hydrogen is quite free from impurity. The gases are collected under slight pressure, and any mixing of the gases is absolutely excluded by the design and structure of the cell.

The anode carbons are stated to last three years, a result due to the suppression of OH migration; the asbestos bags incasing the same last, it is claimed, about the same period of time, which is surprising, as

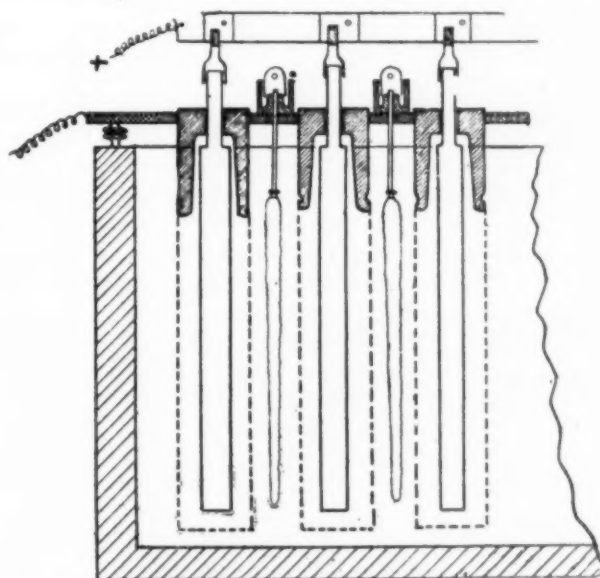


FIG. 20. ANODES AND CATHODE OF BASEL CELL CONNECTED IN PARALLEL

they are in contact with free chlorine. The cathodes and bags are cleaned every six to eight months, since the permeable coatings, especially when employing unpurified chloride solutions, become covered with a thick layer of lime, which lessens the permeability and causes an increase of the voltage. It is unnecessary, however,

to discontinue the working of the cell for cleaning purposes, since each cathode unit and gutter can be lifted out of the containing tank separately, and this can be done also with the single anode bells.

The working of the Basel type of cell is said to be quite simple. The cells are filled up to a certain height with brine, and the electric current is switched on. The propulsive cathodes commence at once their work of circulation, and the caustic alkali solution quickly attains a concentration of 11 to 13 per cent NaOH. A continual supply of fresh brine, corresponding to the quantity of caustic soda solution flowing away, is now fed in at any convenient point; while every propulsive cathode automatically takes the quantity of brine necessary for it, and corresponding to its load of current. The electrolyzers are not heated.

Six electrolytic alkali works in the countries of Central Europe are now employing the Basel type of cell; common salt is being electrolyzed in some of these, and potassium chloride in others.

Electrolytic Alkali and Chlorine Industry in Italy

In Italy, the electrolysis of salt solutions was carried on before the war by three separate companies, two of which employed the Solvay mercury cell, and the third the Outhenin-Chalandre diaphragm cell. The most important undertaking was that located at Caffaro-Falls, and was carried on by the Soc. Elettrochimica del Caffaro. Here the mercury type of cell is employed, with electric power derived from the falls.

The company which operated the diaphragm cell—namely, the Societa Elettrochimica Italiana—has now given up this cell for the Basel type of cell.

The Societa Italiana di Elettrochimica di Rome up to 1918 employed the Outhenin-Chalandre cell, and later a modified form of the Griesheim Elektron cell for its works at Bussi. Owing to the low efficiencies and weak caustic alkali liquors obtained from these types of cell, the company decided early in 1918 to scrap these cells and to adopt the Basel type of electrolyzer.

The new equipment consists of three units of fifty cells, employing a current between 6,000 and 7,000 amp., with an emf. of $3\frac{1}{2}$ to $4\frac{1}{2}$ volts per cell. The new plant is capable of turning out twenty-seven tons of caustic soda per day when the three sets of cells are operated altogether. The consumption of salt is about 1,650 kg. per ton of NaOH, and quadruple-effect evaporators are employed for concentrating the caustic liquors obtained from the cells. The current for each series of cells is provided by a dynamo which generates direct current at 190 to 200 volts. As the waterpower plant at Bussi is capable of generating 6,000 hp., the surplus electric power is at present employed for steam-raising in boilers specially designed for this purpose, and also for the evaporation of the caustic alkali liquors.

The cost of the hp.-yr. at Bussi is stated to be only 55 Italian lire, which at the normal rate of exchange represents \$10.50, whereas coal in Italy today costs from \$20 to \$40 per ton. It is proposed, therefore, to extend the electric heating plant and to employ ultimately 5,000 kw. for these electrically-heated steam-boilers.

The soda solution produced by the cells contains on the average 110 g. NaOH and 200 g. NaCl per liter, with small quantities of chlorate and no hypochlorite. The chlorine contains about 1 per cent CO_2

but is fairly concentrated as it issues from the anode compartments of the cell, and therefore it can easily be liquefied in the special plant installed at Bussi for this purpose.

During the war the Societa Italiana di Elettrochimica di Rome was engaged upon the production of poisonous gases and of other materials for military use. The Bussi works, however, is now free from military control, and in addition to manufacturing caustic soda and liquid chlorine the company is producing the following chemicals:

Chlorates of potash and soda; bleaching powder; hydrochloric acid; hypochlorite of soda; compressed hydrogen; tetrachloride of carbon; tetrachloride of tin; magnetite for electrodes; phosphorus and antimony chlorides; benzylchloride; benzoic acid; barium salts, and finally, several electric-furnace products.

Power is obtained from the two rivers Pescara and Tirino, and 50,000 hp. can be developed at this spot when the necessity for further extensions of the works occurs.

Electrolytic Alkali and Chlorine Industry in Switzerland, Italy, Russia and Belgium

The following is a summary of the position of the electrolytic alkali and chlorine industry in Switzerland, Russia and Belgium before the war:

SWITZERLAND

Switzerland possessed two works of this character; that of the Soc. pour l'Industrie Chimique de Bâle at Monthey being the oldest and most important. Here the Basel type of diaphragm cell, which has been described above, was developed and used; and the output of caustic soda, which was only 1,000 tons in 1913, has been increased to over 2,500 tons per annum.

The other works is that of the Soc. Anon. Suisse de l'Industrie Electrochimique Volta, and is located at Chevres, where electric power from the Geneva Municipal Council's generating plant is employed, with the Outhenin-Chalandre type of cell.

RUSSIA

As regards Russia, several electrolytic alkali and chlorine works had been established there before the war by German electrical engineering firms interested in the production and sale of the plant and machinery. The Griesheim Elektron cell and the Solvay mercury cell were the type employed in these Russian works, which were located at Donetz, at Zabkowsce and at Slaviansk, and in all three cases they were operated by steam power.

BELGIUM

Reference may be made to the works of the Belgian Solvay Co., at Jemeppe-sur-Sambre. This works was established in 1898 for operation of the Castner-Kellner mercury cell, and it was here that the improved type of cell which has now been adopted by the English company at Weston-Point was first operated.

The works at Jemeppe before the war operated twenty-three cells of the large type with 1,500 hp. (steam), but since 1914 it has been closed down. In a letter dated February of the present year (1920), from the head office of the company, in Brussels, the managing director of the firm of Solvay et Cie. states that the works at Jemeppe is not yet restarted.

Operating Details of Electric Furnaces

Excerpt From a Report of the Electric Furnace Committee of the Association of Iron and Steel Electrical Engineers Based on a Questionnaire Submitted to Steel Manufacturers
Operating Electric Furnaces

BY EDWARD T. MOORE

FROM time to time the question arises as to what limit should be set on transformer primary voltage for electric-furnace service. Transformers having a range from 22,000 to 50 volts are common, and from the transformer standpoint there is hardly any reason why the high voltage should not be doubled, tripled or even quadrupled. However, there are other factors that enter into the situation and in this case are the deciding ones.

As soon as we pass 22,000 volts, the type of oil switch necessary for safely rupturing the current changes to a design that is expensive to install and operate in electric furnace service. Accordingly for 44,000 volts and higher, especially in small units, it is desirable to make the first step from the line voltage to 6,600 volts or 2,300 volts, depending upon the circumstances.

AUTOMATIC CONTROL

The task of keeping the power input to an electric furnace constant within reasonable limits by maintaining the position of several electrodes, with their supporting mechanism and flexible conductors, is not an easy one even when all arcing surfaces are comparatively stable, but when half of the arcing surface is made up of numerous pieces of metal constantly changing under the action of the arcs, the difficulties are considerably increased. From the surface of the molten metal there is a continuous spray of small metallic particles which make it easy to establish the arc before the electrode touches the metal, but with solid metal the electrode must practically come in contact before the arc is struck and then it must be drawn away quickly so as to minimize the current surge. This is the condition met in the first part of melting down a charge of cold steel scrap and is a trying time to all parts of the equipment.

Automatic electrode regulators have been in use commercially in Europe for twenty-five years, and in this country about fifteen years, in both places demonstrating to the user their value in effecting better results and conditions generally.

Compared to the inefficient human machine we have a small relay that follows the impulses continuously and the automatic regulator throws a switch as soon as the change takes place in the circuit, the electrode moving almost instantly to meet the new conditions.

In operating an electric furnace it is desirable to keep all surges within the closest reasonable limits, as these surges have, in practically all cases, a definite bearing on the cost of power, and even when this is not considered, such surges affect other users and frequently cause prejudice against all electric furnaces. Momentary surges are limited by electrical characteristics of the furnace circuit, while the duration of the sustained surge is determined by the electrode control.

A sustained surge tends to carry the current density far above the normal carrying capacity of the electrodes, electrode holders and conductors. As the heating varies directly with the square of the current, a current increase of 50 per cent will increase the heating 125 per cent above normal and accordingly shorten the life of any current-carrying member, especially contact surfaces. The electrode consumption is also increased when the power is permitted to vary over wide ranges and surges tend to cause overheating at weak spots in the electrode with consequent deterioration.

In addition to the important consideration given above there are others of almost equal importance, such as the effect on the quality of the product due to widely varying temperatures at the surface of the metal, effect on the equipment, especially the transformers, due to surge strains, etc.

ARRANGEMENT OF ELECTRICAL APPARATUS

With several notable exceptions, practically all furnace equipments are installed in a straight line—that is, the transformers are located directly behind the furnace and the direction of motion during tilting is directly away from the transformers (Fig. 1). While this method of installation requires somewhat longer flexible leads, there are no side strains to the electrode masts and it is comparatively simple to install apparatus in buildings that were designed for other purposes. As opposed to this arrangement we have the design where the furnace tilts at right angles to the line from the transformers to the furnace (Fig. 2), this arrangement requiring considerably shorter flexible leads but giving considerable side strains to the electrode masts.

Where one polyphase transformer furnishes power to the furnace, the busbar layout is comparatively simple, but with three transformers it becomes much more

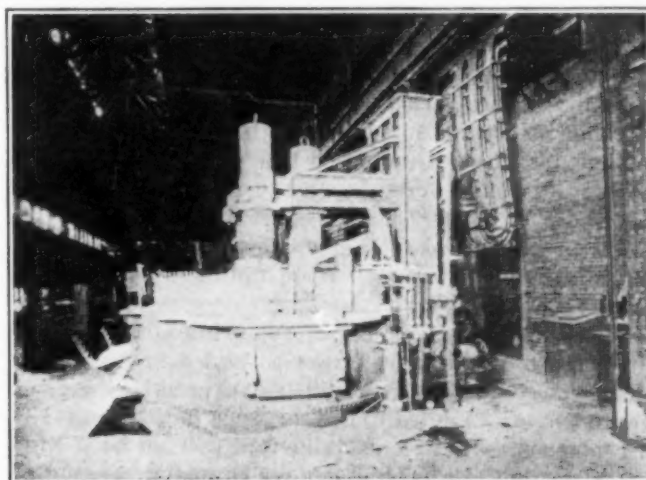


FIG. 1. USUAL ARRANGEMENT OF FURNACE EQUIPMENT

complicated. In this connection come the question of using interleaved buses to point where the delta or Y is formed and the flexible leads taken to the transformer, or whether this connection will be made at the transformers and the added inherent reactance accepted as a necessary evil.

The furnace conductors should be so disposed as to avoid unnecessary eddy current losses which increase the reactance and may cause trouble through distortion of the iron work. Care should also be taken that the panels are kept outside of any magnetic loops or fields, as the instruments may be unfavorably affected.

Busbars are usually self-cooled, but an unusual exception is found on two 10-ton furnaces at Buffalo, where the connections from the cables to the electrode holders

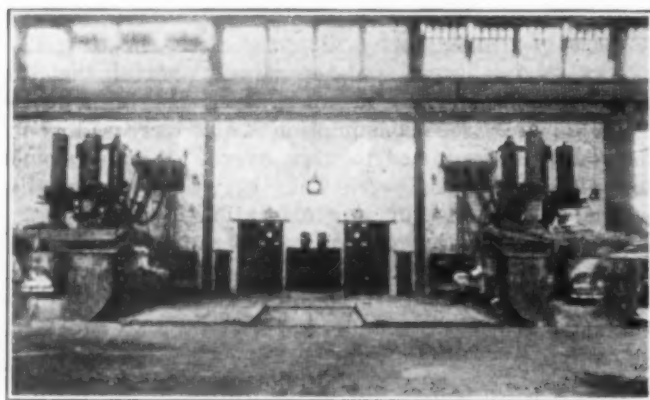


FIG. 2. ANOTHER ARRANGEMENT OF FURNACE EQUIPMENT

are thick-walled water-cooled copper pipes. These conductors have given good service during several years' operation.

Flexible cables are necessarily used between the transformer and furnace buses, and a form of insurance is the use of welded terminals that absolutely do away with shutdowns caused by failure of soldered or brazed terminals.

The current density is usually somewhat higher in the cables, approximately 900 to 1,000 amp., than in the bars, which usually run 750 to 850 amp. per sq.in.

On account of the height of the electrode masts, in those cases where the conductors are carried over the tops, a saving in bus copper can be effected by raising the transformer on a pedestal so that the top of the low-voltage leads is on a level with the top of the masts.

VARIABLE OR DUAL VOLTAGE CONTROL

An important subject is the use of double voltage operation for arc furnaces, not only from the standpoint of range of voltages to be used but also the possible detrimental effect of increased rate of melting, obtained by the use of such voltages, on the quality of the metal.

With small furnaces up to one or two tons capacity, except in special cases, there seems to be little reason for going to the expense of installing apparatus for double voltage control. In larger furnaces, however, there seems to be a good reason for using a high voltage during part of the melting period and a lower voltage during the refining period. With a furnace taking 1,500 kva. the voltage applied to the electrode must necessarily be a compromise between a value that will not be so high as to damage the roof and side walls during refining or so low as to lose too much time during melting.

By the use of double voltage control a voltage can be

chosen for melting that will give the best results for this so-called heavy duty work, while a corresponding value can be chosen for the refining which will give the best results during that important period.

In one installation the greatest power input that could be obtained during the melting down period was 1,800 kw. at 100 volts, while with practically the same furnace design the power input was increased to 3,200 kw. by a moderate voltage increase.

There is a well-defined belief that the high rate of melting obtained by high voltage is detrimental to the quality of the product, especially for tool steel, and this should be carefully investigated. Until the arc shows above the metal, there can be no other objection and possibly the same holds true for the quality of the metal.

REACTANCE

The amount of reactance to be used with an electric furnace; its disposition on high-voltage or low-voltage side; the amount of inherent reactance in the transformers; the kind of reactor, iron core or air core, depend upon the type of furnace, the service and local conditions. The reactance stabilizes the arc and determines the limit of short circuit current. The resistance of the leads, electrodes and charge, being small compared to the reactance, can be neglected in this connection.

AMOUNT

Power factor and reactance are intimately connected and considerable harm has been done by advocating too high a power factor.

Public reference was recently made to the unsatisfactory operating characteristics of a 3-ton, three-phase, 1,000 kva. furnace taking power from a 11,000-volt 25-cycle circuit. On account of the low reactance of this equipment, it is common occurrence for the oil switch to open several times during a heat, and as this switch is set at six times normal current, a reactance of approximately 16 per cent is indicated, which should give a power factor of over 98 per cent, a figure unnecessarily high.

If the reactance was doubled, the power factor would be still approximately 95 per cent, while the short circuit current would be decreased from 600 per cent to 320 per cent. If the reactance was still further increased to 43.6, the power factor would still have the excellent value of 90 per cent and the short circuit current would be 229 per cent. This seems to be a desirable value, although if still better protection is desired, such as on a small capacity privately owned plant, a reactance value of 53.7 per cent would give a power factor of 85 per cent and a short circuit current of 190 per cent. These figures are based on values that would be obtained with a reactance having a characteristic of the air core type and would necessarily be altered for iron core reactors and reactors of the compounding type, such as saturated reactors.

A 6-ton, three-phase furnace having transformer capacity of 1,500 kva. on a 60-cycle circuit will have approximately 90 per cent power factor, indicating a reactance of 43.6 per cent, of which about 6 per cent will be in the transformers. The remaining 37.6 reactance, which is principally in the secondary leads, would be reduced to 15.7 per cent on a 25-cycle circuit. The 25-cycle transformer would have a reactance of about 7 per cent, which, added to the 15.7 per cent, would give a total of 22.7 per cent, indicating a power

factor of 97.4 per cent with a corresponding short circuit current of 440 per cent. This indicates that to give the smooth operation of a 90 per cent power factor furnace a 20 per cent reactance should be added to a furnace that normally requires no exterior reactance on a 60-cycle circuit.

Fig. 3 illustrates graphically the relation between reactance and power factor in a circuit. As abscissæ are plotted reactance voltages in percentage of the supply voltage, while the ordinates represent the power factor of the circuit in per cent. Incidentally, the ordinates of this curve also indicate the voltage drop due to resistance in the circuit, or, neglecting the resistance in the transformer and furnace leads, the actual voltage which is obtained across the furnace electrodes in per cent of the supply voltage.

PRIMARY OR SECONDARY

Except on small furnaces, or very high-voltage circuits, the use of external reactance is practically confined to the high-voltage side. In this location it gives additional protection to the transformer against exterior surges and is easier to install on account of the general arrangement of apparatus.

TRANSFORMER REACTANCE

The inherent reactance of a transformer with normal design is from 4 to 7 per cent and this can be increased without much difficulty up to 20 per cent. If additional reactance is to be installed and it comes within this

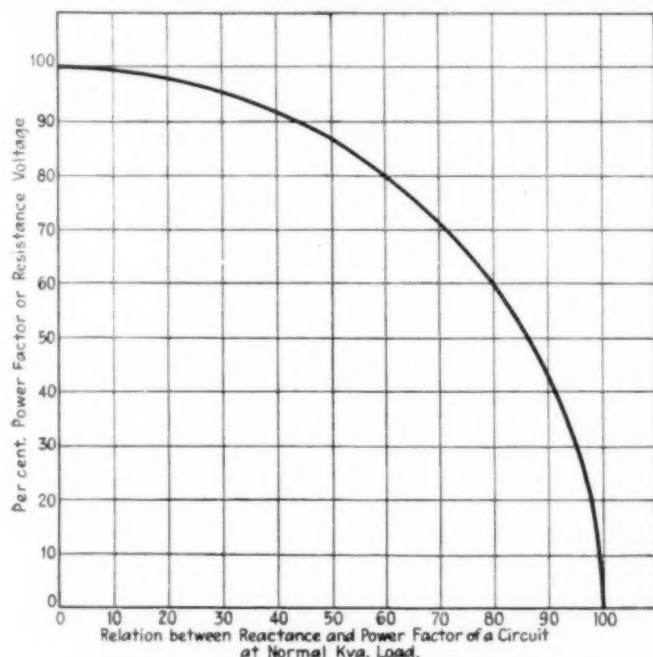


FIG. 3. RELATION BETWEEN REACTANCE AND POWER FACTOR

value, it appears to be a mistake to keep down the transformer reactance and then increase the installation cost by adding external reactance. This is not necessarily the case, as the equipment will be considerably more flexible if the inherent or uncontrollable reactance is reduced to a minimum and desirable characteristics are obtained by the use of external or controllable reactance. This is especially true in installations using variable voltage control, as the amount of reactance necessary to produce the best results at the high voltage would be excessive and produce undesirable characteristics at the low voltage.

Under ordinary circumstances the choice of reactor lies between the iron core type and the air core type, in some cases there being little to choose from the standpoint of price alone.

The iron core reactor is chiefly used in circuits carrying currents of less than about 50 amp., when a reactance of more than 4 or 5 per cent is required. Under such conditions an air core reactor would require a very large number of turns to give the desired reactance, and the iron core design is considerably more economical.

ELECTRODES

The function of the electrode is to conduct electric energy into the furnace and assist in the production of a proper atmosphere for refining of the metal. Since the cost of electrodes will form approximately 9 per cent

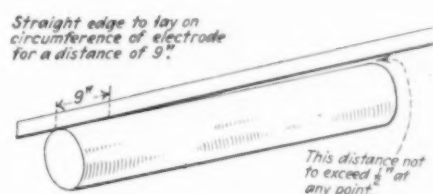


FIG. 4. ELECTRODE

of the total operating expense of a furnace, it will be appreciated that this subject is an important one. This expense will be further increased if excessive breakage is experienced and from the questionnaire below it will be noted this item amounted to an average of 7.7 per cent for carbon electrodes. In addition to this, delays on the furnace due to electrode breakage are costly items and may become prohibitive.

It is believed if more attention was directed toward the proper handling of electrodes by furnace users that excessive breakage would be eliminated and higher economy secured per ton of metal produced. The average consumption of carbon electrodes taken from our questionnaire is 39.9 lb. per ton of metal produced, although there are a number of cases where 30 lb. per ton of metal is an ordinary everyday performance. It would seem as though much improvement could be made toward better electrode economy by better methods of handling and storage of this important material.

One of the large electrode manufacturers has recently published a booklet containing many valuable suggestions for the handling and use of electrodes which we trust will be given wide circulation. With proper handling by the consumer, electrodes should give better service than the average records indicate, for better electrodes are now being made.

Electrodes furnished under this specification are to be amorphous carbon of 14 in. and 17 in. diameter.

Tolerances

Electrodes shall not vary at any point in their diameter over 2 per cent plus or minus from the diameter specified, throughout their entire length, and to be within the following limits:

Nominal Diam., In.	Maximum Diam., In.	Minimum Diam., In.
14	14.28	13.72
17	17.34	16.66

The outside surface of all electrodes to be free of flat spots, bulges, cracks or other irregularities which would interfere with satisfactory operation when placed in the electrode holder of the furnace.

Length

All electrodes furnished hereunder are to be 72 in. long and shall be as straight as possible throughout their length.

No curvature shall exceed $\frac{1}{8}$ in. as determined by using a straight edge which shall engage the electrode for a distance of 9 in. from either end of the electrode. The distance between straight edge and any point on the circumference of the electrode between the $\frac{1}{8}$ in. area and the opposite end shall not exceed the specified variation. See Fig. 4.

Ends

The ends of the electrodes are to be straight and square with the face—that is, a straight edge laid on the end of the electrode would be 90 deg. from a straight edge laid on the face of the electrode for a distance of 9 in. from the end referred to. See Fig. 5.

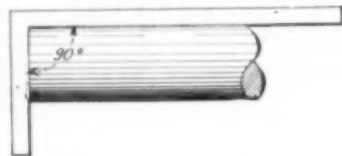


FIG. 5. END OF ELECTRODE

Threading of Electrodes

Electrodes are to be threaded at each end and symmetrical. The center of the threaded portion is to coincide with the center of the electrode so that when two electrodes are jointed together their edges will not project beyond each other.

Screw Plugs

The screw plugs or nipples are to be made preferably of a material different from the electrode in order that greater tensile strength may be secured.

The threads will be machined to fit "free" so that no binding will take place. They shall not be so "free," however, as to allow end play when the nipple is pulled or pushed while in position, but should be tight enough for good electrical contact and not so tight as to cause vertical cracks in the threads of the electrodes or actual breakage at the ends of the electrodes.

Electrical Resistivity

All electrodes are to have an average specific resistance per inch cube at 20 deg. C. of not more than 0.002 ohm and with no single electrode above 0.0025 ohm.

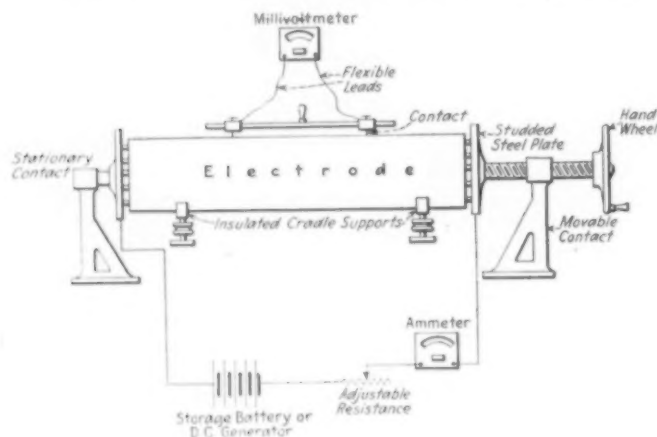


FIG. 6. APPARATUS TO MEASURE ELECTRICAL RESISTIVITY

The value of the test current to be 300 amp. These measurements may be secured by an apparatus similar to that shown in Fig. 6, although in place of the stud steel plate contacts, ordinary copper bands may be used. The contact frame connected to the flexible leads of the millivoltmeter should be pressed firmly against electrode and readings taken at various positions along the length and laterally. The average of all readings to be taken as the basis for acceptance or rejection.

Round Electrodes¹

Dia., In.	Area, Sq. In.	Av. Wt. per 60 in. Length, Lb.	Est. Max. Current, Amp.
6	28	99.5	1200
8	50	171.4	2000
10	79	251.4	3000
12	113	359.9	4500
14	154	479.8	6000
16	201	670.0	7000
17	227	687.9	7500
20	314	966.4	1,000
24	452	1508.0	13,500

¹ National Carbon Co.

The figures given for maximum current are approximate and are such as to allow the electrode to operate "black hot." These figures depend on furnace conditions and may vary widely.

Some manufacturers do not believe that electrical resistivity tests of the electrodes is of primary importance to the user, although we feel that the above specification should include such resistivity tests in order to provide data for future discussion.

Tolerance for graphite electrodes should be as follows:

Graphite Electrodes²

Size of Electrode, In.	Tolerance in Diameter, In.	Tolerance in Bowling, In.	Size of Nipple	Threads, per In.
2		on 24 length	1 1/2 x 3	6
2 1/2		on 30 length	1 3/4 x 4	4
3		on 40 length	1 3/4 x 5	4
4		on 40 length	2 1/4 x 7	4
5 1/2		on 40 length	2 1/2 x 8	4
6		on 48 length	3 1/2 x 9	3
7	under over	on 48 length	4 x 9	3
8	under over	on 48 length		
9	under over	on 48 length	4 1/2 x 10	3
10 x 60	under over	on 60 length	5 1/2 x 11	3
12 x 60	under over	on 60 length	6 x 12	2
14 x 60	under over	on 60 length	7 1/2 x 12	2
		on 60 length	8 1/2 x 12	2

Bowling to be measured across the concave side from straight edge to electrode at middle. The same method for measuring curvature of carbon electrodes may also be used for graphite, with modifications for the smaller diameters.

Resistivity

The average electrical resistivity of graphite electrodes should be 0.00036 ohm per inch cube, or 0.000914 ohm per cm. cube.

Roof Cooling Rings

As a means of securing better electrode economy more attention should be given to roof cooling rings for the purpose of reducing "spindling" and "wasping." At least one of the members of the committee has experimented extensively with rings of various design, but with no very great improvement in results. Several months ago a new type of roof cooling ring was placed on the market and from investigations made on actual installations very great improvement seems to be indicated.

The gases generated in an electric furnace during operation are only combustible at high temperatures, which means that if they escape to the atmosphere, they are hot enough to burn and in doing so burn up part of the electrode itself and also have a very objectionable effect on the electrode holder. Consequently, nearly all the present-day cooling rings have for their principal object the cooling of the electrode and the cooling of the port holes of the roof.

In the cooling ring under discussion there is obtained the desirable feature of keeping the roof port holes cool, keeping the electrode reasonably cool, and go still further by cooling down the gases, as they leave the furnace, to a temperature at which they will no longer burn when they meet the oxygen of the atmosphere.

While these gases are inside the furnace they are under reducing conditions and have, therefore, only their own sensible heat and no heat generated by the oxidation of combustible constituents. These gases pass, first of all, in between the electrode and the port hole of the roof and then pass through clearance A, Fig. 7, in the cooling ring and into a relatively larger chamber B, which causes the expansion of the gases and thereby giving up a large amount of sensible heat in the gases. This heat is absorbed by the water in the cooling ring. From chamber B they are once more contracted through the small clearance C and are passing to a very large chamber D for a second and much larger expansion. This chamber is surrounded, in the case of graphite electrodes, by a thin inclosed cover E, which in actual

²Acheson Graphite Co.

practice has been found quite sufficient to dissipate the heat given up by these gases, and when they finally pass through the clearance *F*, they are no longer at a temperature sufficiently high to cause them to burn in the atmosphere.

The fact that graphite electrodes can be machined allows the use of a very small clearance at the points *A*, *C* and *F*, which in turn allows a much larger relative expansion into the chambers *B* and *D*, and at one installation, where these cooling rings have been under our close supervision, we have found that even during the periods when carbon is being thrown on to the slag for the purpose of deoxidation, there is not the slightest sign of flames being emitted at the point *F*, and the electrodes themselves do not show the slightest trace of reduction in diameter.

When such economizers are to be used on amorphous carbon electrodes, and especially of the larger sizes and

distance *J* can be altered to suit working conditions. This is desirable from the fact that certain types of electrodes may have a greater variation than others and it may be necessary to increase the capacity of the chamber *D*, whereas for the best type of electrode this distance can be kept down to a minimum and thereby not affect the maximum travel of the electrode jib.

The use of this electrode economizer considerably decreases the amount of electrode consumption, and the port holes in the roof also appear to stand up very much better. This is probably due to the blanketing effect and to the fact that the flames do not rush out through the roof. We have also noticed that there is a much less tendency of the electrodes to taper off and they burn square right down to the point of the arc. This means that the electrode always has the correct carrying capacity at its extremity.

In cases where this type of cooling ring are not used, the air coming in through the furnace doors strikes the white hot electrode and the roof openings act as a chimney, the electrode burning away and penciling off. When the tip of the electrode is thus reduced, it has often to carry very much more current than it has been designed for, and the consequences are that the electrode heats up unduly throughout its length and breakages of electrodes and connecting nipples frequently occur.

Experience so far, while limited, seems to indicate that the above objections are very largely prevented by the use of these economizers.

REFRACTORIES

Silica.—Silica bricks are used as an electric-furnace refractory more than other material for the reason that the melting temperature is very high, being approximately that of platinum, or 1,750 deg. C., and stand up remarkably well up to approximately 1,700 deg. C. They are especially satisfactory for roof brick, as they have an expansion when heated of about 0.25 in. per ft., which permits of maintaining a very flat roof. The bricks are made from quartzite with 95 to 99 per cent silica (SiO_2) and when furnished should contain at least 95 per cent silica in order to stand up.

Silica bricks should be laid in a siliceous mud for mortar—in fact, all refractory bricks should be laid in mortar of the same composition as the brick, to avoid fluxing.

Magnesite.—Magnesite bricks are finding an increasingly large use for those parts of the furnace in direct contact with the charge and for parts exposed to extremely high temperature. The finely powdered magnesite is burned so thoroughly that it is sintered and then forced into shape by the use of very high hydraulic pressure. As it shrinks greatly when heated it is again burned before use and can then be kept in storage without fear of spoiling, for it is not so sensitive to moisture.

Basic mortar must be used with magnesite bricks and the courses should be laid as close as possible, so that even with expansion of the mortar the joints may remain tight and expose very small surfaces of attack to harmful influences. It should be noted that under the influence of other materials at high temperatures certain refractories quickly break down. The following rule must be strictly observed: In the presence of basic influence use basic materials, and with acid influences, use acid materials.

Particular attention should be directed to the building

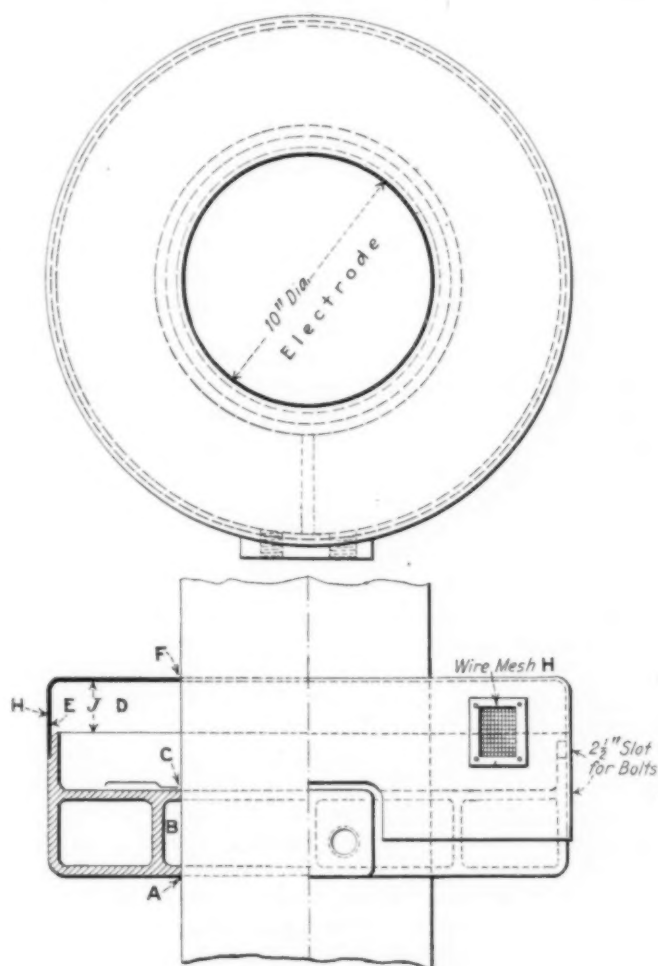


FIG. 7. COOLING RING

of the makes where the diameters do not run to any regularity, a change is made in the chamber *D* of the economizer. The gases there, instead of being all allowed to pass through the clearance *F*, pass through perforated plates *H* on the outer wall of the cover *E*, and by keeping these perforations as small as practical, the plates *H* will act on the principle of the metallic gauze used in Davy miners' lamps, in which it is well known that the heated gases of combustion from the lamp are cooled to such an extent that the lamp can be very safely used in the dangerous explosive gases of coal mines.

The cover *E* will be made adjustable, so that the

of the side walls in a furnace so as not to have them too steep, else it will be very difficult to repair or patch up disintegrated portions.

Very great success has been secured with dolomite in making bottoms for furnaces. It is a limestone containing a considerable proportion of magnesite and when burned forms a valuable refractory, but should be mixed with pitch or tar before ramming into the furnace and used as soon as possible, because of its lime content ($\text{CaCO}_3\text{MgCO}_3$) it readily absorbs moisture from the air and falls to powder.

BRASS FURNACES

The reason for the rapid increase in the use of the electric furnace in the conservative brass industry and for melting other non-ferrous metals and alloys is the production of a uniform metal by eliminating or minimizing operators' errors under the trying conditions of fumes and high temperatures met while handling crucibles, eliminating contamination from furnace gases, preventing loss of volatile constituents through uneven heating and, in general, making a uniform product by superior heat control. Also as we are mixing two or more metals having different specific gravities and melting points, it is necessary to have efficient stirring, and this is accomplished both electrically and mechanically.

Furnaces may be broadly divided into those in which the heat is generated in the metal, those in which the heat is generated at the surface of the metal and those in which the heat is generated externally to the metal and radiated or otherwise transferred to it.

In the first group we have the induction furnace for normal frequencies as exploited by the Ajax Metals Co., of which there are many in successful operation. These furnaces are very efficient and are best adapted to large plants where one or more furnaces can be used continuously on the same class of metal. In small plants, or where several heats are to be made of one alloy and then another composition is required, this type of furnace is at a serious disadvantage, as they are usually started with a charge of molten metal. Intermittent operation of this furnace also has a detrimental effect on the lining and it is practically limited to continuous operation.

Another type that is passing through the experimental stage operates on the induction principle and is designed to take power at 9,000 cycles or higher. The equipment is very simple from all standpoints except the power equipment, which has been the chief obstacle in the development of equipments of commercial capacity. This furnace can melt or heat any metal to any reasonable temperature and should be of great value when fully developed.

In the second group we have furnaces where the current passes from the electrode to the metal, and it is necessary in this case to reduce the voltage drop between the electrode and the metal to such a value as will practically eliminate arcing. This is necessary on account of the intense heat developed by an arc in the surface of the metal, causing tremendous vaporizing losses which could not be tolerated.

The third class includes arc furnaces where the heat is generated above the metal and radiated to it and the refractory walls. By oscillating or rotating the furnace shell, the metal is mechanically stirred and absorbs heat from the refractories, thus tending to keep them at practically uniform temperature.

Other types of furnaces using exterior heating are resistance furnaces where the heat is generated in resistors and radiated or conducted to the metal. The latter types have neither electrical nor mechanical stirring and must depend upon mechanical rabbling together with slight stirring due to heating effect through the lining. Various other types are under development, but they are not of sufficient commercial importance to warrant consideration here.

The consumption of electric energy varies from a reported figure of 174 kw.-hr. per ton in continuous operation on induction furnaces up to 240-500 kw.-hr. for intermittent operation on arc and resistance types.

CONCLUSION

The data secured from the questionnaire indicate very conclusively that the greatest need at present is for better electrode economy, which means watching closely the handling, storing in a warm dry location and proper joining of electrodes. The improvement of the present largely used roof cooling ring will have a big effect on electrode consumption.

Lack of tensile strength seems to be one of the difficulties of electrode trouble caused by the lines of cleavage of the calcined anthracite coal being in a vertical as well as horizontal direction, it being impossible at present to build an electrode where all the cleavage lines are horizontal. Recently some amorphous carbon electrodes have been made with a hard bonding material which increases the density very materially. While their use has been over a period of only six months, preliminary reports indicate a greatly reduced breakage. If some method of placing the material of electrodes in a position to present its lines of cleavage at the best advantage were devised, no doubt practically all breakage could be eliminated.

One of the chief sources of difficulty in furnace operation is delays due to handling material to and from the furnace. This difficulty increases as the number of installed furnaces becomes larger. The practice of bringing the scrap on the surface floor from the rear and adjacent to the furnace in small cars on tracks and using traveling cranes entirely for handling the steel from the furnace is certainly desirable and conducive to reduced delays.

The present method of charging scrap into a furnace by shoveling and peeling means a delay of at least one-half hour. Using an automatic charging machine will reduce the time of charging materially, but it will not be able to place the scrap as uniformly as may be done by hand; therefore, during melting the power fluctuations will be greater. With hand charging, the scrap can be placed uniformly and a greater tonnage treated.

Although considerable work has been done toward perfecting the electric furnace and its accessories, there is opportunity yet for very extensive research, and we believe the necessary results will be forthcoming in the very near future.

Changes in Regulation 60 on Alcohol

A supplement to Regulation 60 relative to dealing in, transportation and use of tax-paid industrial alcohol in original stamped packages only has recently been issued from the Office of Commissioner of Internal Revenue.

Federal prohibition directors and others concerned may obtain the detailed information by writing to the Treasury Department, Office of Commissioner of Internal Revenue, Washington, D. C.

Ternary Brasses

AS LONG ago as 1905, Léon Guillet published¹ some investigations on special brasses, in which he was led to the conception of "fictitious compositions" in an attempt to systematize the results. Thus when adding various percentages of tin to a 60:40 brass, he found that the microscopic appearance of three brasses when slowly cooled were quite similar and consisted of light secondary crystals of γ in a dark matrix of β . These were 54:40:6, 60:30:10, and 46:54. Up to 10 per cent, tin evidently entered into solid solution, and acted like zinc, but with a potency several times as great. In other words, both of these tin-brasses might be thought of as having a "fictitious" composition of 46 Cu, 54 Zn. From the standpoint of the equilibrium diagram, Fig. 1, tin apparently moves points a , b , and c to the left.

Similarly, when studying the ordinary physical properties, tin additions up to 2.2 per cent increase the strength and hardness of 60:40 brass. Ductility and

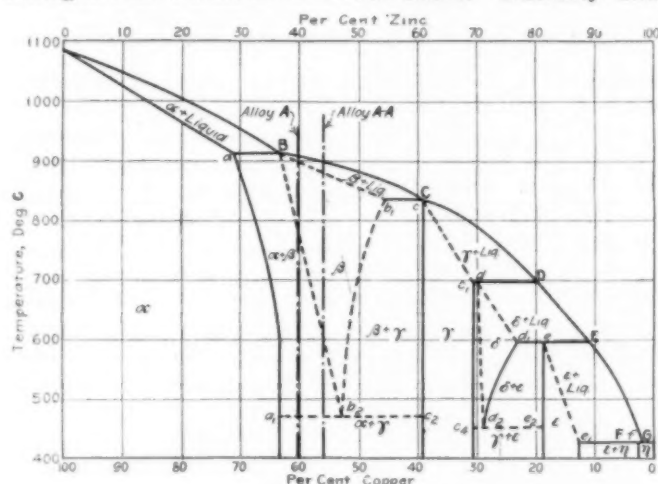


FIG. 1. EQUILIBRIUM DIAGRAM FOR COPPER-ZINC ALLOYS
After Gulliver, "Metallic Alloys," p. 267

shock strength is badly affected when tin is above 1 per cent. All of these changes are in the same direction as they occur when the copper content of the brass is lowered.

Further detailed studies along these lines were published in the following year,² paying especial attention to the effect of aluminum, which appears to be especially powerful in displacing sideways the properties vs. composition curves. As many as nine other metals have been studied as to their effect on brass. Guillet states the general conclusions that on the introduction of a small amount of third metal to a Cu:Zn alloy it enters into solution with the normal constituents up to saturation, but by so doing it brings the ternary alloy into a state microscopically equivalent to a binary Cu:Zn alloy of fictitious composition, and physically more nearly like the latter than the brass containing Cu:Zn in the ratio actually present. Physical properties of the fictitious binary brass, when compared to the same properties of an actual brass of the same composition, are of course modified by the inherent properties of the third element. Beyond the saturation point a special constituent appears, and the above generalization no longer holds.

¹Revue de Métallurgie, 1905, vol. 2, p. 97.

²Compositions give percentage of copper first, then zinc, and lastly of the third metal.

³"General Study of Ternary Brasses," by L. Guillet, *Revue de Métallurgie*, 1906, vol. 3, p. 243.

For example, if a 70:30 brass has 2 per cent aluminum substituted for 2 per cent zinc, the actual composition would analyze 70:28:2. Now suppose 1 per cent Al plays the same rôle as 6 per cent Zn. The proportions of copper and equivalent zinc may then be stated as 70 parts copper and 40 parts zinc, which figured to 100 gives an analysis of 63.6 per cent Cu and 36.4 per cent Zn, the "fictitious composition" for a 70:28:2 aluminum brass.

MATHEMATICAL STATEMENT

Such a relation may be stated mathematically: "A body added to a brass possesses a coefficient of equivalence t when 1 per cent of this body will enter solid solution and replace t per cent of zinc, the proportions thus obtained being figured to 100."

In symbols, let A be the real percentage of copper, B the real percentage of zinc and q the real percentage of the third element.

Then

$$A + B + q = 100$$

Also let A' be the fictitious percentage of copper, B' the fictitious percentage of zinc and t the coefficient of equivalence.

Then

$$A' + B' = 100$$

and

$$B' = \frac{B + tq}{A + (B + tq)} = 100$$

Figuring explicit functions for A' , q and t from these expressions one gets

$$A' = \frac{100A}{100 + q(t-1)} \quad \text{for figuring the fictitious composition of a given ternary brass.}$$

$$q = \frac{100}{t-1} \left(\frac{A-A'}{A'} \right) \quad \text{for figuring the quantity of third metal to be added to } A \text{ brass to approximate the properties of } A' \text{ brass.}$$

$$t = 1 + \frac{100}{q} \left(\frac{A-A'}{A'} \right) \quad \text{for figuring the coefficient of equivalence of a metal of which } q \text{ per cent changes alloy } A \text{ to approximately that of } A'.$$

DETAILED STUDY OF ALUMINUM BRASSES

As noted above, the second publication gives the details of an extensive study on aluminum brasses to illustrate and verify the general ideas thus expressed. In the first place the coefficient of equivalence was determined approximately, then verified by synthesis of a typical brass, and finally the mechanical properties were studied—tensile strength, Frémont impact, Brinell hardness, and forgeability.

Varying amounts of aluminum were added to a 60:40 brass, the resulting alloy analyzed chemically, and examined micrographically. From such data t can be calculated. Some results follow:

Chemical Analysis—		Microscopic	t Calculated
Copper	Aluminum	Analysis Copper ¹	
59.6	0.3	59	6.1
59.9	0.8	57.5	6.2
59.6	2.9	50.5 to 54.75	7.2 to 4.1
Average about.....			6.0

Given this value of t , it was verified by trying to pro-

¹The microscopic appearance of the ternary alloy approximated to within plus or minus 1 per cent the appearance of a binary alloy with copper as indicated. In other words, this table might be headed A' .

duce ternary alloys whose compositions were equivalent to certain well defined microscopic appearances. Thus:

Given Copper	Figured Al	Required A'	
70	2.22	63	β constituent first appears
60	1.92	54.75	Traces of α constituent
60	3.76	50.5	A little γ is seen

As the result of many trials the following data were determined by chemical and micrographical analysis:

A	q	A'	t Calculated
70.3	2.3	63	6.04
59.8	1.65	55	6.27
60.4	4.7	50	5.42

Average..... 5.91

which was regarded as checking the round number 6.0 sufficiently well.

Higher aluminum alloys were also analyzed:

A	q	A'	Calculated t
68.47	4.50	56.0	5.94
68.49	5.60	53.0	6.21
78.73	7.14	57.0	6.33

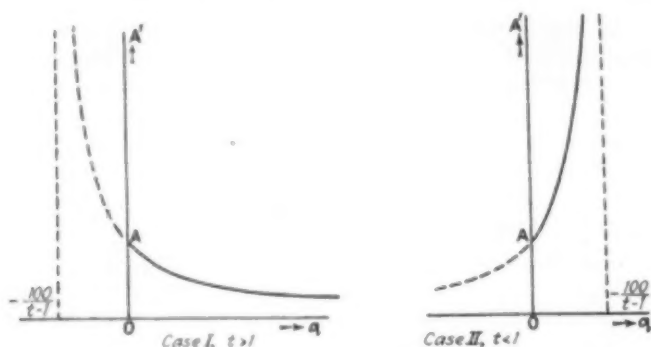
A third series of tests varied the amount of copper in an attempt to retain the same structure.

Aimed at			Analyzed			A'	t Calculated ²
A	q	A'	A	q	A'		
70	4.4	57.3	69.6	4.95	56	55.7	
65	2.7	57.3	66.4	3.0	58	57.7	
60	0.95	57.3	59.9	1.17	56.5	56.5	

A great many test-bars were broken in an attempt to correlate and systematize the observed data. From these results the following trio are typical.

Cu	Al	Fictitious Cu	Ultimate	Elastic Limit	Elongation	Contraction	Impact Strength	Hardness
64.73	1.64	58.8	51,200	17,600	38.0	40.7	10	69
57.96	.....	.....	50,600	9,400	44.0	49.9	13	73
64.7	.....	.....	30,300	5,700	55.0	53.8	17	39

Evidently the physical properties of the ternary brass are more nearly those of the simple brass of fictitious composition than that with the same percentage of copper. From all these tests it is plain that in industrial



FIGS. 2 AND 3. GRAPH SHOWING RELATIONSHIP BETWEEN AMOUNT OF THIRD METAL AND FICTITIOUS COMPOSITION

brasses (with greater than 55 per cent copper) aluminum increases the breaking strength and elastic limit, but if added even in small quantities to 58 per cent copper brasses it may render the product worthless by bringing in the brittle γ solution.

²On the basis that $t = 6.0$.

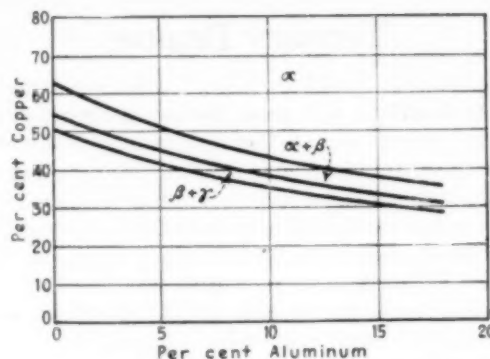


FIG. 4. TERNARY DIAGRAM FOR ALUMINUM BRASSES

GRAPHIC REPRESENTATION

Equation $A' = \frac{100A}{100 + q(t-1)}$ if plotted in A' and q will assume the form of an equilateral hyperbola asymptotic to horizontal axis (q) and a parallel to the A' axis at $q = -\frac{100}{t-1}$. There are two cases, of course, as shown in Figs. 2 and 3, the first where t is greater than 1, and the second where it is less than 1. If $q = 0$, $A' = A$, and in the former case as q increases A' becomes less than the real copper analysis. If t is less than 1 it is evidently useless to add a greater quantity of the third element than $-\frac{100}{t-1}$; however, one or more special constituents due to supersaturation would ordinarily intervene long before.

A ternary diagram for aluminum sketched on these principles is given in Fig. 4. The asymptote is at -20 .

RESULTS IN VARIOUS ALLOYS

Similar detailed studies were made by the author on many addition metals; the details can be consulted in *Revue de Métallurgie*, 1906, vol. 3, p. 243. It must suffice here to tabulate the results obtained, together with notes as to the limits of usefulness of Guillet's generalization—that is, the analysis where a special constituent appears in the alloy. Nickel brasses have further been studied in great detail, and have been briefly reported in 1913² and more fully in 1920. Extensive summaries of these papers will be presented in subsequent issues of *CHEMICAL & METALLURGICAL ENGINEERING*.

TABLE OF RESULTS

Element		Special Constituent Appears *
Al.....	6.0	7.1% in 69% Cu
Mn.....	0.5	8% in 60% Cu
Fe.....	0.9	?
Sn.....	2.0	0.7 up to 63% Cu, 9% at pure Cu
Pb.....	1.0	0.9% in all brasses
Si.....	10.0	1.4% up to 63%, 2.0% @ 90%
Mg.....	2.0	0.25%
Sb.....	?	0.4%
Cd.....	1.0	0.9% (much like lead)
Ni ²	-1.3	None
Co.....	Variable ²	4.3

Such studies should simplify the ideas covering special brasses, and make their fabrication the more dependent upon reason—especially for the forgeable alloys. Required physical properties may therefore be reached by simple analyses, replacing highly expensive and delicately worked alloys of high complexity.

²*Revue de Métallurgie*, 1913, vol. 10, p. 1130.

²*Revue de Métallurgie*, 1920, p. 494.

H. Foster Bain Becomes Director, Bureau of Mines

IN ASSUMING the directorship of the Bureau of Mines left vacant by the resignation of Dr. Cottrell to become chairman of the Division of Chemistry and Chemical Technology of the National Research Council, H. Foster Bain brings to his new duties a full realization of the importance of the chemical work of the bureau. As a matter of fact, one of the first big questions which came before him was in regard to this phase of the bureau's activities. The Committee on Appropriations had just reported out the sundry civil bill, omitting the items which had been requested by the bureau for extended work in the interest of the chemical industry. That made it necessary to lay plans immediately for renewed efforts in behalf of the industry which has taken on such increased importance since the outbreak of the war.

Mr. Bain was born at Seymour, Ind. After his graduation from Moore's Hill College, Indiana, in 1890, he spent two years at Johns Hopkins University and later received his doctor's degree from the University of Chicago. He was educated and trained as a geologist and mining engineer. He was one of Herbert Hoover's assistants in London on the Belgian relief work during the war. From 1909 to 1915 he was the editor of the *Mining and Scientific Press* of San Francisco, Cal., and later the editor of the *Mining Magazine* of London, England. He made some important mining investigations in south and central Africa and later undertook similar investigations in China. At one time he was a mine operator in Colorado and once was connected with the U. S. Geological Survey. Subsequently, he was the first director of the Geological Survey of Illinois.

In addition to Mr. Bain's contact with British mining affairs, during his residence in England as editor of the *Mining Magazine*, he has been engaged in consulting work in the Rand, the Belgian Kongo and other mining regions of Africa. He also has had considerable experience in the Far East. During the two-year trip from which he has just returned he made mining examinations in ten Oriental countries.

While Mr. Bain is more widely known for his work in geology and as a mining engineer, he has given far more attention to chemistry than has the average consulting mining engineer. While at Johns Hopkins University he received special training in chemistry under Prof. H. N. Morse in addition to the chemical work connected with the regular courses in metallurgy. At Cripple

Creek in 1901 he conducted a series of experiments on the cyanidation of Cripple Creek ores. He was among the first to attempt the heating of solutions. This practice has since developed some importance in connection with certain ores. At a later date he did extensive work on South Dakota ores in connection with the controversies which have arisen over patents covering cyanidation and concentration. Mr. Bain points to these early efforts as an indication of the relatively larger amount of duplication which took place before the work of the Federal Government provided a clearing house which enables all concerned to have the benefits of current developments, thereby speeding the perfection of improved processes. In connection with Mr. Bain's South Dakota work, it later developed that practically the same problems were being worked out at the Homestake Mine.

Just at present Mr. Bain is carefully considering the question of the character of research which should be undertaken by the Bureau of Mines. He is weighing the arguments advanced by manufacturers that the Government's research too frequently encroaches upon a field which properly belongs to private industry and believes that a definite line can be drawn where there will be no such encroachment. His study of the subject, however, has not reached the point where he is prepared to make an announcement of the bureau's future policy in that regard.

An incident in Mr. Bain's earlier experience brought home the fact that human relations as well as applied science are involved in every engineering project. After receiving his doctor's degree he sought employment as a shift boss in a mine with the idea of gaining first-hand experience in that phase of prac-



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H. FOSTER BAIN

tical operation. He took charge of a gold-silver operation known as the Franklin mine in Clearcreek County, Colorado. The mine labor employed was Italian. Some friction had arisen as to the selection of a night shift boss, the first Sunday after Mr. Bain's arrival. The affair had given rise to a serious fistic encounter which kept Mr. Bain busy during his day of rest in negotiations with the keeper of the jail and the physician in charge of the hospital. This was followed a few days later by another phase of the feud in which work on the property was stopped by a concealed rifleman who amused himself by making the mine mouth his target. Finally, however, Mr. Bain got things running smoothly as far as open hostilities were concerned, but he learned that mining involves a great deal more than a knowledge of engineering and geology. In fact his first task on that job was to teach the men to use hammer drills, which were just coming into use at that time.

Current Events

in the Chemical and Metallurgical Industries

Dyes and Coal-Tar Chemicals in 1919

The Census of Dyes and Coal-Tar Chemicals for 1919, which has been issued recently by the Tariff Commission as Tariff Information Series 22, is indeed a report of progress in these essential industries.¹ Outstanding features of the census have been given in the preliminary summary by Dr. Grinnell Jones, published in *CHEM. & MET.*, vol. 23, p. 661, Oct. 6, 1920.

INTERMEDIATES

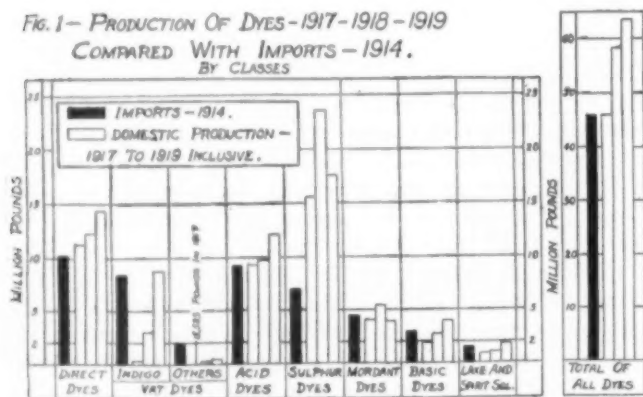
The decrease in the production of intermediates from 357,662,251 lb. in 1918 to 177,362,426 lb. in 1919 can be traced almost entirely to the diminished demand for products used primarily for explosives. The most spectacular case is that of phenol, which dropped from 106,794,277 lb. in 1918 to 1,543,659 lb. in 1919. In this report intermediates are grouped as benzene, toluene, xylene, naphthalene, anthracene and carbazole compounds, each group being subdivided whenever possible into classes of derivatives, such as halogen, nitro, amino, sulphonie acid, hydroxyl, etc. It is interesting to note that the production of anthraquinone in 1919 (294,260 lb.) exceeded the production of anthracene (purity of 25 per cent or over) in 1918 (225,552 lb.). The corresponding figure for anthracene in 1919 is 1,381,944 lb.

Another helpful innovation in this section is a list of intermediates used in the production of developed or coupled dyes directly on the fiber and in printing. Many of these compounds were sold before the war under trade names, such as Developer J and Reserve Salt O, and this list gives the chemical name corresponding to the trade name in the hope that customers will be able to obtain the materials more reasonably and that it will also help intermediate makers to supply those not yet made in this country.

DYES

Besides the itemized table showing a production of 63,402,194 lb. of dyes, valued at \$67,598,855, there is

Fig. 1—PRODUCTION OF DYES—1917-1918-1919
COMPARED WITH IMPORTS—1914.
BY CLASSES



included a comparison of 1914 imports with the production of dyes by classes in 1917-1919 inclusive. This is shown graphically in Fig. 1. It will be noted that the

classification is based upon the method of application on the fiber.

One hundred and ninety-one firms reported a total of 24,736 employees engaged in the manufacture of coal-tar products, of which 2,605, or 10.5 per cent, were chemists or engineers. This is probably a larger proportion of technically-trained men than will be found in any other important manufacturing industry in the United States. The group of employees receiving \$40 or more per week included 57.4 per cent of the technical men, but only 12.7 per cent of those without technical training. Corresponding figures for \$75 or more are 12.67 and 0.14 per cent respectively.

RESEARCH WORK

Of the total of 214 firms, 65 had separately organized research laboratories for the solution of technical problems in the manufacture of their products and for the discovery of new products. During 1919 the net operating expenses of these research laboratories, together with the cost of research work done in laboratories not separately organized for research, was \$4,274,247. This includes salaries, apparatus and materials, after deducting the value of salable products made in research laboratories. This figure is probably an understatement of the real cost of experimental work, since it does not include in all cases work of this nature done as a part of manufacturing operations and is not shown on the books of the companies as a charge against research.

CONDITIONS IN OTHER COUNTRIES

Beginning with February, 1920, detailed statements of one-quarter of the monthly production of every dye in each German factory were made to Reparations Commission, as required by the peace treaty, Annex VI, Part II. A classified summary of these reports from February to October, 1920, is published in this report by permission of the Department of State. A progressive increase is shown in each succeeding month to a maximum of 3,026,247 lb. in August, which indicates a total output of over 12,000,000 lb. per month. The rate of production from July to October inclusive is only about one-third of Germany's pre-war output.

Conditions in England, Switzerland, France and Japan are also briefly reviewed.

IMPORT STATISTICS

Information as to the importation of individual dyes is given in Part III of the report, which is a census of dyes imported into the United States during the fiscal year 1920. The Schultz and Julius number is given wherever possible, together with the name of the manufacturer. The companies listed include thirteen German, six English, four Swiss, two Dutch, one French and one Belgian. The imports total 3,501,147 lb., with an invoice value of \$4,458,109.

The names of 171 firms which manufactured coal-tar products during 1919 will be found in the appendix to this report. Coke-oven plants and gas houses which reported to the Geological Survey are not included.

¹Copies of this report may be obtained for 20c. from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Chemical Tariff Schedule Under Consideration

Schedule A, that portion of the tariff which includes such chemicals, oils and paints as are not on the free list, was the subject of hearings on Jan. 6, 7 and 8. Judging from the attitude of the committee during those hearings and those which have followed, it seems apparent that the intention is to frame promptly a tariff bill which will provide rather arbitrary rates due to inability to ascertain accurately the costs of production abroad and to the difficulty of forecasting the economic situation either at home or abroad. The bill probably will be enacted with a full understanding that it is to be amended frequently as conditions may change.

DOMESTIC MARKET VALUE CONSIDERED AS BASIS

There is very decided sentiment in favor of ad valorem duties to be based on the market value of the commodity in the United States. Apparently the majority of the committee would like to see this plan tried. It is admitted, however, that many obstacles must be surmounted to make the plan effective. To start with, it will be necessary to scrap the intricate governmental machinery which has been built up through a long period of years for making valuations in foreign countries. There is objection on the ground that it will be unwise to disband such an organization in order to experiment with American valuations. Another difficulty arises in the fact that a large proportion of imports are specialties which are not manufactured in this country and on which it will be difficult to fix a fair American valuation.

DATA ON FOREIGN PRODUCTION COSTS UNRELIABLE

Those who have testified before the committee have had a great deal to say about cost of production abroad and most witnesses, in response to questions from the Democratic side of the committee, have stated that all they want in the way of tariff is a rate which will equalize the costs of production. In the face of cross-examination, it has developed that little accurate information is available as to costs of production abroad. The question is further complicated by the exchange situation and from the fact that currency has one value in foreign exchange and entirely another value when it comes to purchasing labor within the country of issue. Moreover, foreign costs are undergoing violent fluctuations.

FURTHER DEPRESSION MUST BE AVOIDED

Republican members of Congress are outspoken in their desire that great caution be used in framing this tariff law. If excesses are permitted to creep in and the rates are made too high, the effect of the law in increasing prices to consumers in the time of depression will react to the disadvantage of the party and the protective tariff idea. It is recognized that at present there are a large number of influences at work tending toward depression. With a new tariff act in the spot-light, it probably would be blamed for a condition for which it could be only partly responsible.

CONSUMING INTERESTS WELL ORGANIZED

Never before when a tariff bill was in the making have the consuming interests been so well organized. The successful outcome of the fight made by some of the textile interests on the dye bill is an indication of the skill with which opposition to tariff can be brought to play on such commodities as are used by powerful aggregations of consumers.

The consensus of opinion among those who were in attendance at the hearings on the chemical schedule is that the case was splendidly presented to the committee. There is abundant evidence that the committee is particularly sympathetic with the necessity for protecting the chemical industries. It is understood that the chief point of Democratic attack will be on other schedules. It is regarded as practically certain, however, that there will be some material reductions in the rate of duty requested by domestic manufacturers.

STATEMENT OF MANUFACTURING CHEMISTS ASSOCIATION

Henry Howard of the Grasselli Chemical Co. opened the hearings on the chemical schedule with a general statement for the Manufacturing Chemists Association. He pointed out that the manufacturing chemists appearing were confining themselves to articles not covered by the pending dye bill. He pointed out in the beginning of his statement that the problem is not alone one of depreciated foreign currency or of low foreign exchange, but is one of low wages. He said that German labor now costs half what it did before the war. He said that the development of the chemical industry is the best index of the progress of civilization in a country. He called attention to the fact that chemical development is predicated on continued systematic research carried out at great expense by the most highly trained experts obtainable. This sort of work is possible only when the industry is in a prosperous condition, because a number of years usually are required before there is any cash return from the products of research.

SPECIFIC VS. AD VALOREM

Mr. Howard made a plea for specific rates rather than ad valorem rates, where the substitution is possible, so as to simplify the administration of the act. He called attention to the fact, however, that in many cases two or more specific rates should be provided. He used this illustration:

Paragraph 73 of the 1909 act provided: "Sulphide of soda, containing not more than 35 per centum of sulphide of soda, $\frac{3}{4}$ of 1 cent per lb.; sulphide of soda concentrated or containing more than 35 per centum of sulphide of soda, $\frac{3}{4}$ of 1 per cent per lb." In the act of 1913 this dual classification was abandoned and a flat rate of $\frac{3}{4}$ of 1 cent per lb. substituted, with the result that only the concentrated product, 1 lb. of which was equal to 2 lb. of the crystals, was imported at a rate designed for the crystal or unconcentrated variety. This concrete instance is given as being typical of a great many and shows the advisability of providing two or more specific rates in all cases where it is possible to substitute a more concentrated or more valuable product for the one in common use at the time the tariff is written.

NEED FOR ANTI-DUMPING LEGISLATION

Mr. Howard emphasized the necessity for providing anti-dumping legislation. In that connection he said:

The association notes with approval the passage of the Fordney anti-dumping bill H.R. 10918 through the House of Representatives, Sixty-sixth Congress, second session, and the introduction of the Smoot anti-dumping bill in the Senate, as indicative of the intent of Congress to legislate on this most important matter, and most respectfully urges upon the Committee on Ways and Means that the next tariff act contain adequate and complete provisions along the lines of the Fordney and Smoot bills, bearing in mind that in our best judgment, no remedy against dumping will prove adequate unless it operates immediately and automatically at port of entry.

Chairman Fordney for the committee stated that it is the intention to make the anti-dumping bill a part of the tariff act if the Senate does not pass it before the

tariff bill comes before the House. In that connection Mr. Fordney stated that it is the intention to report the tariff bill to the House not later than April 10.

ALUMINUM SULPHATE AND BAUXITE SITUATION

In the course of his testimony on behalf of the makers of heavy chemicals, S. W. Wilder of the Merrimac Chemical Co., Boston, said:

We believe the 1913 duty is inadequate to protect our industry and we have special reasons why we may expect that importation from now on of sulphate of alumina and allied compounds will increase. It is a fact that in Europe the production of sulphuric acid has been greatly increased since the war, and sulphate of alumina is a very natural vehicle for disposing of sulphuric acid, and we feel that this country may become a dumping ground for that product.

Mr. Wilder opposed a duty on bauxite. Due to the quality of imported bauxite, he said it would be a serious matter to put a duty on it. Representative Rainey, a member of the committee, took occasion to interpose the following with regard to the Aluminum Company of America:

That company started out as a \$90,000 corporation a few years ago, and now it is a \$10,000,000 corporation, controlling the production of aluminum in Canada as well as in the United States, and probably also in the world.

SUGGESTIONS ON AMMONIA

Among the recommendations made by William H. Bower of the Henry Bower Manufacturing Co. of Philadelphia was the following:

We would also suggest that aqua ammonia be transferred from the non-enumerated paragraph to a paragraph covering ammonia and its products at a specific rate of 1½c. per lb.; liquid anhydrous ammonia, 5c. per lb. This would show a duty per pound of ammonia in ammoniacal gas liquor of 2c.; of aqua ammonia 5c., and a calculated ad valorem for liquid anhydrous of about 14 to 15 per cent. The ammonia industry is an important one in this country, and serves the refrigerating trade by which our foodstuffs are stored and preserved.

Frederick W. Russe of the Mallinckrodt Chemical Works, St. Louis, declared that low priced chemicals are emanating in great volume from Germany, England, France and Italy. "We do not know," he said, "whether it is due to the cost of production, unloading or dumping. At any rate, they have their catalogues and lists down in South America, and they are taking the business that we and other manufacturers have developed before the war and during the war due to these abnormal conditions that are now existing."

MEDICINALS PRESENT SPECIAL PROBLEMS

In giving reasons why medicinal chemicals should be especially regarded in a tariff bill, Donald McKesson of McKesson & Robbins, New York, said:

Medicinal chemicals, owing to their nature and the care with which they have to be produced, chemicals for internal administration or hypodermic administration, require extreme purity, and therefore they cannot be manufactured on a very large scale. You cannot use the ordinary automatic apparatus which can be used on a large-scale manufacture. The workmen have to be intelligent and skilled, they have to be very closely supervised by high-grade chemists, who are very hard to obtain. Our chemical training in this country is not as high as it is abroad, and we have to require our chemists when we employ them to study further to increase their knowledge before they are really as efficient as they should be.

In reply to a question as to what proportion of his costs is labor, Mr. McKesson said:

I would say the average would be about 40 per cent or more; we went up to 75 per cent on some products. Our manufacture being almost entirely of medicinal chemicals, the cost is higher than suggested by Mr. Rosengarten previously, who also manufactures the heavier chemicals, where the cost of labor is very much lower.

He also testified to the effect that professional men in Germany are in desperate straits and are working for very low salaries. In addition he said:

Another reason for protection, or, rather, another reason why there should be a great endeavor in foreign countries to export to the United States is that it is absolutely necessary for them to establish credits in the United States, even at a sacrifice, and they are going to try and get the goods in here at any price they can get them in.

Germany, since the war, has increased her syndicate system. They are consolidating all of their factories, and they have their pools from yellow-dog funds, and everything they had before they are working in the same way to an intensified extent. That is a situation that we cannot reach on account of the Sherman law.

An example of a question put to numerous witnesses is shown by the following colloquy between Representative Garner of the committee and August Kochs, of the Victory Chemical Works, Chicago:

MR. GARNER. You are willing to take the difference between the cost of production here and abroad and take your chances with the foreigner?

MR. KOCHS. Yes, sir; absolutely, as a matter of business, and I think every manufacturer should be willing to do that.

POSSIBILITY OF RETALIATION IN CASE OF CAMPHOR

An interesting exchange took place between Representative Rainey and Nathan M. Clark, vice-president of the Celluloid Company, and representing the Pyroxylin Manufacturers' Association. It follows:

MR. RAINEY. Did it ever occur to you that Japan might retaliate and put an embargo on this camphor?

MR. CLARK. That might be entirely possible, and we could not ask this committee to help us in that instance, as we can now, with a tariff.

MR. RAINEY. If you put on a tariff high enough to keep her manufactures of camphor out of this country, why cannot she put an embargo against your raw camphor?

MR. CLARK. Yes; but then we would die by her blow and not by a blow from our committees.

MR. RAINEY. Then if we passed a tariff which would keep her manufactures of camphor out this market and she retaliated by putting an embargo on your raw material, you would be out of business entirely?

MR. FREAR. We have heard about those bugaboos before.

MR. RAINEY. It is not a bugaboo; it may actually happen.

MR. CLARK. We believe that is a potentiality, but we feel we would rather meet it the other way first.

By allotting all the way from two to fifteen minutes to each witness, a large number of representatives of the chemical industry were given an opportunity to appear before the committee during the hearing. Each discussed the necessity for protecting the products of his own manufacture.

TARIFF INFORMATION SURVEYS

In connection with the hearing, the United States Tariff Commission has furnished a series of tariff information surveys covering the greater portion of the commodities contained in the tariff act of 1913. The fact that the Tariff Commission was able to assemble and have printed, on such short notice, such comprehensive information has brought forth much favorable comment.

Edgar Fahs Smith, New President of the A. C. S.

Like Robinson Crusoe, Dr. Edgar Fahs Smith, the new president of the American Chemical Society, was born at York, but there the analogy ends. Robinson Crusoe went off by himself. Dr. Smith couldn't do such a thing, because there is no spot on earth so isolated or so distant but that many alumni of Pennsy would surely follow after him and before he had his hut half-way built they would be surrounding him, unhooking their ribs and opening their hearts, seeking advice. He has always been a teacher of chemistry, and while his laboratory methods are in use wherever chemistry has entered industry his whole career and activities have been academic. Born in Pennsylvania, he studied at Pennsylvania State College, where he took his degree as bachelor of science at the age of eighteen. At twenty he had achieved his Ph.D. at Göttingen, and since then he has been decorated nineteen times or more by various universities here and abroad, so that he is a twenty-fold doctor.

AS TEACHER AND AUTHOR

He was instructor in chemistry at the University of Pennsylvania from 1876 to 1881, professor of chemistry at Muhlenberg College 1881-83, at Wittenberg College 1883-1888, and from then on at the University of Pennsylvania again. From 1889 to 1911 he was vice-provost of the same university, and its provost from 1911 until last year. Although administrative duties interfered seriously with research, his contributions to the knowledge of electrochemistry, of electrolytic methods for the separation of metals, and of electrolysis generally have made him a leading authority in respect to these subjects. He is the author of several monumental works on electrochemistry, has translated Richter's inorganic and organic reference books; he has made signal contributions to the chemistry of tungsten and its compounds and has contributed with his advanced students over one hundred original papers to chemical literature. Besides this and more he has written a number of volumes of supreme merit which are biographies of leading American chemists of days that are past. We have spoken before of them. They distinguish the subjects of whom he writes. It is a good thing to give thanks unto the Lord, says the Psalmist, and we venture to add that it is also a good thing to know how to do it. Dr. Smith has this gift of words for tribute, for appeal, and for exposition, but he does not misuse it.

HONORED BY MANY SOCIETIES

Aside from membership in many learned societies, he was president of the American Philosophical Society for four years, from 1902 to 1906, and was once before, in 1898, president of the American Chemical Society. In 1914 he received the Elliot Cresson Medal from the Franklin Institute.

RETAINS HOLD ON ALUMNI

As a teacher Dr. Smith has had, in addition to unusual familiarity with his subject, a remarkably keen and appreciative understanding of his objects—who were his students. He knew his young men, and they knew that he knew them. When a new provost was to be chosen he was practically the unanimous choice of the alumni. He straightway became famous among college presidents by keeping every alumnus of the university posted by fre-



EDGAR FAHS SMITH
President American Chemical Society

quent personal letters as to what the university was doing. He proved himself also a faithful and competent administrator.

AN ADEPT AT EXPOSITION

He has a whimsical sense of humor which he employs in exposition, and he is singularly able to make clear the truth in regard to science and its use in everyday life in a manner at once simple and direct. Thus, while his activities have always been academic, his interests are unbounded and his sense of industry is practical and sane. There is no dilletantism in the questions he asks when he visits a chemical factory. His mind is somewhat of the Franklin type, being at once alive with curiosity, constructive in its working and habit, philosophical in its ordering, and yet always open, and usually with a little leaning toward the homely things of everyday life.

These expressions in regard to Dr. Smith have been gathered after diligent inquiry among the alumni of the University of Pennsylvania and from one of the leading educators of America, who is head of another important institution of learning.

British Columbia Paper Possibilities Interest Capital

A number of influential eastern Canadian pulp manufacturers have been in Victoria conferring with the officials of the British Columbia Government with a view to obtaining certain concessions in connection with the erection of two or three large pulp mills in the province. Provided satisfactory arrangements can be made, it is proposed to build a mill at Prince George which, it is said, will cost in the neighborhood of \$6,000,000.

New Tanning Process for Australian Shrub

A shrub growing principally in the gold fields of Australia has been found to possess properties suitable for tanning purposes, according to the *World Salesman*. Leather tanned by the extracts from this shrub is adjudged equal to the best, being especially useful in lining hats. Some excellent samples of fast dyes have also been extracted from this shrub. An extensive area has been granted a new enterprise by the West Australian minister for mines, over which the company will strip the bush to feed a tanning and extracting works.

The Woodpile and Its Relation to the Paper Industry

The Connecticut Valley branch of the Cost Association of the Paper Industry held its regular monthly meeting on Jan. 10 at the Hotel Nonotuck, Holyoke, Mass. Dr. Hugh P. Baker, secretary and treasurer of the American Pulp and Paper Association, was the principal speaker, and had for his subject "The Woodpile and Its Relation to the Paper Industry."

Dr. Baker reviewed the history of the forests in this country, particularly in New England, and pointed out that at first the forests were believed to be inexhaustible and that at times timber was cut down and burned up that the settlers might get at the land. To illustrate what the price of woodland was not long ago, the speaker told of exchanging in his early boyhood forty acres of timber for a bicycle, and said that he got the better of the bargain, taking into consideration that plenty of good woodland could be had at that time for 50c. an acre. It is only within the last two or three decades that forestry has been put on a scientific basis.

It has been claimed that the paper manufacturers have been using up the forests, but statistics show that only 8 per cent of the forests are being used for paper pulp purposes. Ten years ago the person who spoke of the need of reforestation would have been regarded as a theorist, but today the paper manufacturers realize that their industry is dependent upon forestry, as only 2 per cent of the paper made in the U. S. is of all rag stock.

A number of pulp manufacturers in the East have been forced to go into Canada for timber lands, and paper manufacturers are now importing wood pulp from Finland and Scandinavia. This would not have been necessary had we had a proper reforestation policy. The state of New York spent \$140,000,000 for lumber last year and 85 per cent of it came from the South and other states. Only 32 per cent of the land of New England is being farmed. There is enough idle land east of the Ohio River alone which, if properly reforested, would not only provide in time all the lumber that we need, but provide an export supply.

Reforestation in the case of hardwood is not so urgent, as there are large stands of these at present, but the shortage of rapid-growing evergreens for pulp-wood purposes is becoming acute. Reforested lands are about four times as prolific as virgin land and a cutting for pulp purposes could be made in about sixty to seventy-two years. To illustrate that reforestation could be made a profitable business venture, Dr. Baker said that in Germany before the war tenant farmers were being made to vacate the lands, as the owners could make more on their investments by planting forests.

He spoke of the Snell forestry bill now before Congress and said that bill, he hoped, would be passed at the next session and would form the charter of reforestation for this country and mark the first definite

step of the United States for forestation. "Not an industry can get along without our forests," he said, "and I hope to see these New England states great forest states through reforestation of tracts now idle."

Industrial Relations Conference

A large number of manufacturers, industrial relations managers and business executives attended a conference of the Industrial Relations Association of America on Jan. 7 at the Hotel Kimball, Springfield, Mass., at which was advocated a more intimate relationship between employer and employee in all connections, for the sake of more harmonious relations and consequent greater production. The meeting was held as a district convention of the association in co-operation with the Employment Managers Association and the Chamber of Commerce of Springfield.

Colonel B. A. Franklin, vice-president of the Strathmore Paper Co., West Springfield, Mass., was one of the principal speakers at the morning session. In order to obtain lower labor costs, he advised maintaining the best working conditions possible, and stated that adequate lighting of plant, maintenance of health and correct mental attitude of all employees were important factors making for the most pleasant places to work.

An informal discussion followed the afternoon session, at which presidents of the associations in different cities spoke. C. V. Derrick, employment manager of the American Bosch Magneto Corporation, Springfield, Mass., expressed a wish that the higher managers of the factory attend conferences of foremen and of other employees. F. M. Marsh of Boston noted the development of leaders among the employees as a growing function of the industrial relations manager. Mr. Ching of the United States Rubber Co. and Mrs. Jane Williams spoke on "What Readjustments Are Needed in Personnel, Service and Employment Work Under Present Conditions." C. J. Yeomans of New York spoke on "What Does Personnel, Service and Employment Work Mean to the Management?" Howard Cheney of the Cheney Silk Mills, South Manchester, Conn., discussed "New Problems in Industry and How to Meet Them."

Among the practices advocated by the several speakers as sound business were: Make the employee feel you are telling him the truth in all matters; work on the golden rule; a square-deal basis for all concerned; courtesy in meeting all men who apply for work, whether there is work or not; make it possible for foremen to handle labor problems within their own walls.

Nichols Medal Awarded to Dr. G. N. Lewis

The conferring of the Nichols Medal upon Dr. Gilbert N. Lewis of the University of California, by the New York Section of the A. C. S., which was to take place at the Chemists' Club, New York City, March 11, has been postponed until May 6, 1921.

This medal is awarded for some particularly important article which appears during the year in the *Journal* of the American Chemical Society and is to be bestowed upon Dr. Lewis for his paper entitled "The Third Law of Thermodynamics."

Chemicals Sold as Surplus Property

Chemicals, acids and explosives to the value of \$3,703,586.66 were sold prior to Jan. 1 by the director of sales of the War Department. This does not include chemicals, acids and explosives transferred or sold to Government departments or agencies.

Production of Camphor in the United States

Two of the largest consumers of camphor in the United States, E. I. du Pont de Nemours & Co. and the American Celluloid Co., have essayed to defeat, at least in part, the monopoly which the Japanese Government maintains on the supply of camphor by growing their own. This fact was brought out Monday evening, Jan. 10, by William R. Webb, assistant superintendent of the chemical plant of the Eastman Kodak Co., in his talk on "Camphor, Natural and Synthetic" before the Rochester Section of the American Chemical Society.

In 1910 the American Celluloid Co. set out a camphor-tree grove of 3,000 acres in Florida, and five years later the du Pont company began a much larger camphor-tree farm in the same state. The trees are pruned each year and the clippings distilled. From them nearly 2 per cent of their weight in camphor is obtained. When the trees stop growing rapidly they are cut down and the whole tree is distilled for camphor. In the meantime younger trees are kept ready to take the places of the older ones.

The Japanese Government controls the harvesting, reforestation and distilling of its camphor trees. At one time it produced practically all of the camphor used in the world, which is variously estimated at 10,000,000 lb. a year. To overcome this monopoly Germany and France began competing with the natural product through artificial camphor produced in their chemical plants from turpentine. The war stopped the production of this synthetic camphor, so that today the groves in Florida are the most formidable competitor of the Japanese monopoly.

January Meeting of the Indiana Section, A.C.S.

At the January meeting of the Indiana Section of the American Chemical Society at Indianapolis on Friday evening, Jan. 14, Dr. F. O. Anderegg of Purdue University gave a talk on "Activated Nitrogen, Hydrogen and Oxygen." It was pointed out that these elements are in very stable molecular form, oxygen being the least inert of the three. Nitrogen is extremely inactive and hydrogen is between the others in activity. If some way can be found to activate these gases, then many reactions which do not occur under ordinary conditions can be brought out. The simplest way to activate most substances is to raise the temperature. Another very important method of activation is to use a catalyst. That subject is so great, however, that it was not discussed further, but the time was devoted to the description of several other methods.

In many chemical reactions where these elements are set free a certain proportion of the atoms or molecules come off in an activated condition. Thus "nascent" or active hydrogen is given off during the rapid solution of metals by acids, and the amount of activated gas is increased by speeding up the reaction. Sometimes electrolytic hydrogen is also very active. Similarly ozone, the commonest form of activated oxygen, is produced under favorable circumstances when acids act on peroxides, during electrolysis and during the slow oxidation of phosphorus or arsenic by moist air. There is always produced in nitrogen from the decomposition of ammonium nitrite some activated form which in contact with an alkali yields nitrates. The suggestion is made that this is initially the result of activated nitrogen.

Another method of activating substances is by ionic bombardment in the electric discharge. This, of course, is the common method of ozone manufacture and can be extended to other gases as well. Nitrogen synthesis by both the arc and silent discharge processes should be included here, and also the so-called synthesis of gasoline as covered by the Cherry patents. A very interesting activated nitrogen is that extensively studied by R. J. Strutt in England. This was produced by a condensed discharge at reduced pressure in pure nitrogen and has many interesting chemical effects. Certain Germans thought that the effects observed were due to the presence of oxygen and the discussion waxed hot and heavy until they all got together in London just before the war broke out and Strutt's claim of the production of the active form from pure nitrogen was vindicated. It was also found that a trace of many foreign gases greatly

accelerated the activation. Recently at the University of Chicago Dr. Wendt and Dr. Grubb have produced and studied a still more active form of nitrogen in the silent discharge. It is hoped that the study of activated gases will aid in the understanding of the structure of atoms, which is today a most fundamental problem.

Dr. I. H. Derby, director of the chemical division of the Republic Creosoting Co., spoke very ably supporting "a movement to establish the co-operative relation between science and the industries in Indiana." Dr. Mahin of Purdue University acknowledged the benefits to both the state industries and the universities of such a proposal and described the present status of the question at Purdue.

T.A.P.P.I. Prepares for Annual Meeting

The executive committee of the Technical Association of the Pulp and Paper Industry met in New York last week and completed preliminary arrangements for the annual meeting and banquet of the association, to be held in conjunction with the annual meeting of the American Pulp and Paper Association at the Waldorf-Astoria and the Hotel Astor, New York, during the week of April 11 to 15, 1921.

The convention will open with informal meetings of the executive committee and the chairmen of standing committees on Monday, April 11. The first general session of the association will convene in one of the meeting rooms of the Waldorf-Astoria at 10 a.m., Tuesday, April 12. The second general session in the afternoon will be devoted to the reading and discussion of scientific papers.

On the evening of Tuesday, April 12, at the Hotel Astor, the annual banquet will be given, at which Judge Charles F. Moore will be toastmaster.

The third general session of the annual convention of T.A.P.P.I. on Wednesday will feature symposiums on pulverized fuel and steam economy, conducted by Howard S. Taylor, chairman of the committee on light, heat and power; and new methods of grinding wood, conducted by the committee on groundwood, of which W. E. Munro is chairman.

Other symposiums, discussions and special papers for Wednesday and Thursday afternoons will be announced later.

Changes Considered in Methods of Industrial Alcohol Distribution

Whether or not changes in the present procedure in distributing industrial alcohol are advisable is being considered by a committee representing industrial alcohol producers. The appointment of the committee was the outgrowth of a meeting Jan. 19 with Prohibition Commissioner John F. Kramer. Mr. Kramer is anxious to know if illegal uses of this alcohol can be safeguarded further. The committee having the matter under consideration is made up as follows: Chairman, Henry J. Kaltenbach, New York, vice-president T. Fleischmann Co.; F. M. Harrison, United States Industrial Alcohol Co.; G. M. MacDowell, National Cereal Beverage Association; Charles Bacharach, Jefferson Distilling & Denaturing Co.; Albert H. Selling, David Berg Industrial Alcohol Co.; V. M. O'Shaughnessy, Rossville Distilling Co.; H. M. Gaylord, Kentucky Distilleries & Warehouse Co.; G. F. Dieterle, Federal Products Co.

Discussion of Western Metallurgical Problems

Dorsey A. Lyon, supervisor of stations, and other Bureau of Mines general officers, the superintendents of the Western experiment stations, Messrs. Van Barneveld, Duschak, Lind, Ralston and Varley, and the deans of co-operating mining colleges, Messrs. Butler, Probert, Lincoln, Merrill and Roberts, met in Berkeley, Cal., during the week of Jan. 24 for discussion of the work in hand and that contemplated by the bureau. Careful consideration was given to all phases of co-operative work of the bureau, colleges and industry, particularly any action designed to stimulate investigational work and the maintenance of close contact. "Flotation" was discussed by Dr. S. C. Lind, "A New Source of Alumina" by O. C. Ralston, and "Production of Sponge Iron" by the round table.

Status of the Nitrogen Corporation Bill in the House

Passage by the Senate of the nitrogen corporation bill removes none of the obstacles which face the bill in the lower house. On receiving the bill from the Senate, the House referred it to the Committee on Military Affairs, which has been considering the House bill on that subject. Representative Kahn, chairman of the committee, states that the bill will not be reported to the House until hearings have been held. Since the Military Affairs Committee has other matters before it which must be disposed of first, no effort has been made to fix a date for these hearings. Some are of the opinion that the bill will die in committee, but apparently the advocates of the bill are in the majority. The ranking Democrat is Representative Dent, of Alabama. Representative Anthony, of Kansas, ranks next to the chairman, and several other influential members are from agricultural sections which are advocating the passage of this legislation. A very influential member of the committee is Representative Fisher, of Tennessee. While there is much doubt as to the outcome of the struggle certain to take place in committee, it is apparent that the pigeonholing of the bill is by no means a foregone conclusion.

It is believed very generally that the bill can be passed in the House if it is brought to a vote. With the exception of Representative Mann, of Illinois, the Republican leaders in the House are understood to be opposed to the measure. With the end of the session approaching, however, the friends of the bill are in a position to exert great pressure on these leaders. If the bill is taken up in the House, it is believed it will be amended in several important particulars. One amendment doubtless will be the relief of the corporation from that provision of the Senate bill which requires it to make a profit from its inception. Another amendment doubtless will be to override the Senate in the matter of precluding Army officers from serving on the board. Undoubtedly the proponents of the legislation would predominate among the conferees, with the probability that the Senate conferees would recede on the more important of the House amendments. By the time the conference report is submitted, it is certain to be late in the present session, thereby offering a splendid opportunity for conducting a successful filibuster against the adoption of the conference report.

The bill, as passed by the Senate, has been put under the microscope during the past week by both its friends and its enemies. Due to the extensive way in which the bill was amended, it now is somewhat disjointed and contains a number of minor errors and conflicts, which, however, can be straightened out in the House and in conference. It is admitted that the provision of the bill making it necessary to pay 5 per cent interest on a sum equivalent to one-half of the original cost of the property cannot be complied with, especially during the first year of the corporation's existence. It was pointed out that it would be unfair to make the corporation pay interest on that considerable portion of the plant which would not be used by it.

It will be recalled that the Ordnance Department has been interested only in having the plant operated. Every effort was made to lease it to private interests. Arthur Glasgow spent six months of intensive effort to obtain a lessee, and at one time it appeared as though the United States Steel Corporation would lease the plant. Then came the suggestion that the Government operate the plant and with it was coupled later the agitation for the sale of the product as fertilizer. Whether or not the nitrogen corporation bill becomes a law, the Ordnance Department expects to redesign and reconstruct one of the units of No. 1 plant for experiments with the Haber process. Ordnance officials do not accept the frequently repeated statement made on the floor of the Senate that the cyanamide process has become obsolete. They point out that the cyanamide process continues in active use at thirty plants in eight countries, while the Haber process is in use nowhere outside of Germany. It is regarded as significant that the favorably located cyanamide plants in Germany are continuing to operate.

The amendment providing that no Army officers shall serve

on the board of the nitrogen corporation is criticized on the ground that each side in the controversy has recognized that the only excuse for the corporation is the fact that it would be in the interest of national defense. Even those who are most interested in obtaining fertilizer at the lowest possible cost admit that the principal purpose of the plant is to enable the country to secure nitrogen for war uses. Under those conditions to bar Army officers from the board is held to be on a par with another amendment to the bill which cut out the research laboratory provision. The laboratory would be essential to the full utilization of the plant for the advancement of knowledge as to the military aspects of nitrogen fixation.

There seems to be no objection in War Department circles to the provision of the bill which limits to 150,000 tons the amount of the nitrate reserve which may be sold. In this connection, it must be noted that it is 150,000 long tons, while current prices usually are quoted in short tons. With sterling exchange rising, and with other indications that Chilean nitrate will advance in price, some figure that \$9,000,000 is the probable realization which could be obtained from this 150,000 long tons of Chilean nitrate. Since the corporation would not need all of its money at once, the sale of the reserve could be spread out over a considerable period, so as not to demoralize or seriously affect the market. There has been considerable controversy over the Army's estimates made in connection with the nitrogen corporation project. The officers who made them call attention to the fact that sight is being lost of the prices and factors which prevailed at the time they were made.

Personal

Dr. MILO C. BURT, formerly of the ribbon factory of the Remington Typewriter Co. and of the Aetna Explosives Corporation, and WALTER R. HIBBARD, formerly of the U. M. C. Works of the Remington Arms Co., Inc., have opened a consulting and research laboratory in the McMahon-Wren Building, Bridgeport, Conn., under the name of Burt & Hibbard, Inc.

Dr. CARL J. ENGELDER, formerly chief chemist for the Pennsylvania Gasoline Co., is now assistant professor of analytical chemistry at the University of Pittsburgh, Pittsburgh, Pa.

Dr. COLIN G. FINK of the Chile Exploration Co., New York, will speak before the Pittsburgh Section of the American Electrochemical Society on "Modern Developments in Metallurgical Research," on Friday, Jan. 28. The meeting is to be held at the Mellon Institute, and will be preceded by a dinner at the University Club of Pittsburgh.

A. F. GREAVES-WALKER, production manager of the American Refractories Co., Pittsburgh, Pa., has been appointed chairman of the Refractories Division of the American Ceramic Society to take the place vacated by the resignation of A. V. Bleining.

Dr. OTTO KRESS, chairman of the committee on dyestuffs, Technical Association of the Pulp and Paper Industry, who has been in charge of the section of pulp and paper at the Forest Products Laboratory, Madison, Wis., for several years past, will resign from the service soon to accept a responsible position with the Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis.

Dr. S. A. MAHOOD, who was in charge of research on wood cellulose and essential oils at the U. S. Forest Products Laboratory, Madison, Wis., has resigned to become associate professor in charge of organic chemistry at Tulane University, New Orleans, La.

Dr. E. E. MARBAKER, formerly chief engineer of Alexander Bros., Philadelphia, has accepted the position of chemist to the Cleveland Wire Division of the National Lamp Works of the General Electric Co.

HOMER F. STALEY, of the ceramic department of the Bureau of Standards at Washington, has resigned to be-

come affiliated with the Metal & Thermit Corporation, 120 Broadway, New York City, as ceramic engineer.

Dr. S. A. VONSOCHOCKY, general technical director of the Radium Luminous Material Corporation and the Radio Chemical Corporation, both of New York, has been elected president of the former company.

F. R. WADLEIGH, who has been export sales manager for Weston, Dodson & Co., Inc., has entered private practice as a consulting engineer. He is prepared to act in an advisory capacity on matters pertaining to the production, market and use of coal.

Dr. E. W. WASHBURN, director of ceramics at the University of Illinois, Urbana, Ill., has been appointed editor of the *Journal of the American Ceramic Society* beginning with the current year.

Obituary

EDWARD T. MCHUGH, for many years president of the McHugh Foundry Co. of Holyoke, died on Jan. 9, at the age of seventy-nine. Mr. McHugh's first important work was undertaken for the Government during the Civil War when he was stationed at Chattanooga, Tenn., in charge of reconstruction of railroads destroyed by the Confederates.

FERDINAND SCHLESINGER, head of the Newport Chemical Co., Milwaukee, Wis., died suddenly at Albuquerque, N. M., at the age of seventy. He was on his way to Pasadena, Cal., accompanied by his wife and son. Mr. Schlesinger was chairman of the board of directors of the Milwaukee Coke & Gas Co. and the Steel Tube Co. of America.

Current Market Reports

The Chemical and Allied Industrial Markets

New York, Jan. 24, 1921.

Actual trading in heavy chemicals during the past week has been very slow. However, there continued to be signs of a renewal of live interest. Improvement was noted in the extent of inquiries for miscellaneous chemicals. The slow but steady absorption of resale stocks has placed the market in a distinctly stronger position. The continued increasing strength of the alkalis is one of the most hopeful signs, and leading interests in the trade believe that this strength will soon spread throughout the general list of heavies.

The unceasing request from domestic consumers has forced manufacturers of *caustic soda* and *soda ash* to reduce prices on contracts. It is stated that the revision is not warranted by any lessened cost of production, but leading makers are willing to step in line with the general trend of affairs in an effort to stimulate business for forward shipments. The open quotation for *solid caustic soda* is now \$3.60 per 100 lb., basis 60 per cent, f.o.b. works, while 3½c. per lb. is the inside figure for round lots over the balance of the year. This cut represents a minimum of 15c. and a maximum decline of 25c. per 100 lb. *Light soda ash* is offered on contract at \$1.72½ per 100 lb. in single bags, basis 48 per cent, f.o.b. works, against a former figure of \$1.82½. Both chemicals on the spot market displayed a stronger tendency. Resale *caustic soda* is still obtainable below producers' prices, owing to the accumulated stocks in the hands of dealers, while the scarcity of *light ash* in second hands has forced the market to about the same level as that named by producers.

The demand for additional quantities of *white arsenic* has not been very active of late. Moderate offerings are obtainable at prices ranging from 11c. to 11½c. per lb. for domes-

tic material, while as low as 10½c. could probably be had on limited offerings of foreign. Resale lots of *formaldehyde* are in the market at prices ranging from 18c. to 19c. per lb., although most dealers are not eager to quote under 18½c. Producers quoted contracts at 20c. Manufacturers named 6¼c. per lb. as the inside figure for standard *copper sulphate*, 99 per cent, in car lots. Outside makes occasionally reached the market at a trifle under this price, but there does not appear to be a great deal of material around. The inquiry is rather quiet at present and somewhat below that of recent years at this time.

Prominent sellers of *copperas* reported sales of prime goods on a basis of \$25 per ton f.o.b. works. It is doubtful whether any round lots could be purchased on the spot market under 1½@2c. per lb. Sales of *yellow prussiate of soda* were reported at 17½c. per lb. and a few odd lots down to 17c. The tone of the market is firmer, however, and resale offerings are not as free as noted at the beginning of the month. Producers are asking 18c. for contracts, but admit that the inquiry for future shipments is rather quiet at the present time. Resale offerings of *caustic potash*, 88-92 per cent, are in the market at prices ranging from 14c. to 16c. per lb. Producers are quoting considerably above this figure, but admit that the demand is very light and confined solely to contract deliveries. There are sellers of foreign material for prompt shipment from Germany on a basis of 10c. per lb.

Sales of imported *tartaric acid* were reported at 33c. per lb., spot, duty paid, for the crystal variety. The powdered is quoted higher and sellers are asking 35@37c. per lb. Demand has not shown much activity of late and the feeling is still irregular regarding the future course of prices. Fused 60-62 per cent *sodium sulphide* is quoted by dealers at 5½@5¾c. per lb. for resale goods. The broken grade is considerably higher, and it is doubtful if much material could be obtained under 7c. per lb. The single strength crystals are now offered freely and the market remained more or less unchanged at 3½c. Sales of *sal ammoniac*, white, granular, 99 per cent, were reported down to 8½c. per lb. on spot. At the close of the week there were sellers at 8½@9c. per lb. The demand has not been of any considerable volume so far and sellers were able to get business only by granting considerable price concessions.

COAL-TAR MARKET

Considering the increase in both inquiries and orders from different quarters of the market during the past week, many are led to believe that a period of improvement is ahead, and broader trading can be expected. Producers of various materials are holding to their views on prices and practically no reductions are announced. Most factors expect to see prices forced higher by the increasing activity among textile mills. While business in the woolen trade has not as yet shown much activity, it is expected that a better buying movement will be noted upon the naming of new prices by the American Woolen Co.

Trading in *dimethylaniline* was confined to a light volume. Producers are firm in their views on prices at 65@75c. per lb. Second hand lots are not being offered in any liberal quantities. The market in *dinitrotoluene* still holds to routine trading in small lots. There has been very little change in price on this item for some time. Quotations range from 27c. to 30c. per lb., depending on seller. Supplies of *H acid* are reported available in more quarters than recently noted and figures vary depending on sellers. In one direction \$1.30 was asked for a limited quantity, while leading producers named \$1.60. The demand for spot goods remained quiet and there was little talk on futures.

While the volume of trading in the market on *aniline oil* is still confined to small lots, the general tendency is toward a higher level of prices and where heretofore 23c. was readily done, the price is said to be harder to locate and 26@28c. per lb. was more generally quoted. The lack of any demand for *diphenylamine* seems to persist and with a fair volume of goods available, the market looked weak with quotations at 65@70c. per lb. The *anthracene* market attracted a little more attention during the past week in both offerings and inquiries. Domestic producers are not

thought to be in any better position on supplies and prices on the 80 per cent are quoted at 85c. @ \$1 per lb.

There is very little change noted on *beta naphthol* of late and offerings are again noted at prices that show shading on producers' quotations and range from 35@40c. per lb. Prices on *paranitraniline* were named by producers from \$1 to \$1.05 per lb. for prompt delivery, with \$1.10 named on contract. Spot lots are around the market from second hands at figures well below manufacturers. The general quotation ranged from 90c. to 95c. per lb.

No change in *benzene* has been noted in the market. Prices in producers' hands remain around 30@35c. per gal. in drums and 28@32c. per gal. for the 90 per cent grade. Buying has been very limited on account of the slowness in consuming industries. *Naphthalene* producers are holding 9c. per lb. as the standard contract price over the year. There are lots to be had from dealers as low as 8c. per lb. for prime white goods, but it is understood that lots at these figures are being held more firmly and that in many cases holders have advanced their ideas to 8½@8¾c. per lb. No further imports have been noted, but stocks of foreign and domestic are still heavy in many quarters. The former price of 9c. per lb. on *phenol* is becoming increasingly hard to do, as stocks on spot are being cleaned up. Offers generally are made around 9½@10c. per lb., with more at the higher than at the lower figure.

The Chicago Market

Chicago, Jan. 21, 1921.

Heavy chemical prices in general have remained firm, the most notable exception being *blue vitriol*, which has been weakened by the low price prevailing in the copper market. Spot sales are recorded at 6½c. per lb. for large crystals, and ½c. less for the small. Demand for small quantities is constant. All of the soda products have remained firm in price, all indications pointing to the practical elimination of second hand stocks. *Soda ash* on immediate delivery is quoted at \$2.20 per 100 lb. Contracts are reported at \$1.82½ per 100 lb. for 48 per cent f.o.b. works. *Caustic soda* has changed hands on the spot at as high as 4½c. per lb., but 4½c. is probably more near the average market. Contracts are offered at \$3.75 per 100 lb. f.o.b. producing point. *Sal soda* is in poor demand, with price unchanged at \$2@ \$2.25 per 100 lb. Current demand for *bleaching powder* seems well covered by contracts which range around 3½c. per lb. Spots are offered somewhat lower, but little interest is shown.

Formaldehyde is easier and is reported as offered at 22c. per lb. in cars f.o.b. factory. Resale stock is offered at considerably below the market. *Alcohol*, *ethyl* grade, remains unchanged at \$5.10 per gal. for 190 proof, but *methyl* grade and *denatured* are both sharply off. Light demand on *denatured* has forced the price down to 68@72c. per gal. *Methyl*, 97 per cent, is down to \$1.35 per gal. Production is being sharply cut as large stocks are said to be in the hands of both producers and second hands. *Glycerine* remains quiet, as offers remain firm at 20c. per lb. for c.p. grade. *Quicksilver* remains weak, \$45 per flask representing the top of the market.

Chlorate of potash is on an uncertain price basis, the domestic being quoted at 16½@17c. per lb. for the crystals, and ½c. less for the powdered. *Caustic potash* is quoted all the way from 15c. to 20c. per lb. for domestic goods, with but few sales being closed. Imported goods are offered at much lower prices. *Carbonate of potash*, calcined, is offered at 14@17c. per lb., with little business resulting. *Chlorine*, liquid gas, is being bought in limited quantities only, and is quoted unchanged at 9@10c. per lb. *Salt cake* is in limited supply and price for immediate delivery ranges around \$53 per ton. *Sulphuric acid*, 60 deg., is quoted at \$15 per ton, but demand on this, as on other heavy acids, is light on the market.

VEGETABLE OILS

There is little doing in oils, as consuming factors have reduced operations to a minimum, operation being quoted as running below 25 per cent in most lines. *Linseed oil*

remains at 94c. per gal. in 1 to 5 bbl. lots from jobbers' stock and is quoted at around 80c. in carlots in cooerage. Actual sales of *coconut oil* in quantity have been made at 10½c. per lb. and Coast quotation is 9½c. for Manila, in sellers' tanks. Demand is better than has been noted for some time. *Corn oil*, offered at 6½@6¾c. per lb. f.o.b. works, attracts no attention, and the same is true of *cottonseed oil* at 5½@6c. for crude f.o.b. Texas points. Partial resumption of the textile industry holds some promise of better business in *red oil*, but no current market is in evidence.

NAVAL STORES

Contrary to general expectation, the advent of the new year failed to bring any renewal of activity in naval stores. Rosin and turpentine are equally quiet, the utter lack of export trade causing stocks to accumulate all along the line. *Turpentine* is quoted by jobbers in less than 5-bbl. lots at 96c. per gal.

COAL-TAR PRODUCTS

Business is utterly quiet, but prices are held firm, apparently because there is no hope of inducing business even through the medium of price cutting. *Naphthalene* is almost a drug on the market, quantities of imported material being available at 7½@8c. per lb. for the flakes and 9@9½c. for balls. Domestic is not so plentiful, and commands 1@1½c. per lb. higher price. Second hand holdings are confined principally to imported goods. *Toluene* at 35@37c. per gal. is in demand in routine quantities only and *benzene* seems a little more desired at 36c. than was the case a few weeks ago. Practically the entire line of intermediates may be covered in one phrase—no business. Prices are being held firmly, but it is probable that real money would secure radical concessions. The one exception is *aniline oil*, which is meeting fair demand at 25c. per lb.

The St. Louis Market

St. Louis, Jan. 21, 1921.

While there has been no startling increase in activity in the St. Louis market during the past two weeks an optimistic feeling is still very much in evidence. Quotations in practically no instances are showing any signs of weakness, though there has not been a very great demand. Producers give two reasons for this condition, one being a lowered production of some items and a resultant decreased stock. The other reason is the confidence that when demand does begin it will be concerted and prove more than equal to the stocks on hand.

Shipments on contracts have improved recently but are still slightly under normal. Contract renewals at current prices continue to be frequent but spot business has not recovered from its coma.

Shipments of the 98 deg. *sulphuric acid* have bettered and the quotation is holding firmly at \$24 per ton f.o.b. works. There is a lively market for the 66 deg. *sulphuric acid*, more sales being recorded for this strength than for any of the others. Producers are quoting \$20@\$21 per ton and 1½c. per lb. in carboys, both prices at plant in St. Louis. The demand for the 60 deg. *sulphuric acid* has become quiet again but prices are being held at \$16 per ton and 1½c. per lb. in carboys. There have been a number of inquiries for *oleum*, but as far as a real demand is concerned the market is quiet. The current quotation is \$28.50 per ton.

Muriatic acid is in fairly good demand, with supplies on hand continuing low. Producers are asking 1½@2c. per lb. in carboys and \$25 per ton in bulk lots.

Quietness is the prevailing note in the *sodium bisulphate* market, with a flash of activity interspersed occasionally. Shipments have been quiet also. The current price is \$7@\$8 per ton.

Nitric acid has been very quiet, with quotations unchanging. The accepted prices are \$7 per 100 lb. for the 36 deg. test and \$10 per 100 lb. for 42 deg. *Standard mixed acid* is quoted at 1½c. per lb. of sulphuric content and 11½c. per lb. of nitric acid content.

Zinc chloride is slow at \$4.15 per 100 lb. for the 50 per cent test. U. S. Government supplies of *phenol* are being offered by a St. Louis producer at 12½c. per lb.

The Iron and Steel Market

Pittsburgh, Pa., Jan. 21, 1921.

Demand for steel has not increased, either in the open market or against contracts. Generally speaking there is a decrease, making comparison with the average of December.

While the double market in steel products ended with 1920 by the independents coming down to the Steel Corporation level in prices, the Steel Corporation and the independents are in totally different positions. The independents seem to have expected a redistribution or leveling up process to occur, whereby they and the Steel Corporation would be in much the same position. Instead, there is a wide divergence. The independents are operating at about one-fourth of capacity on an average, while the Steel Corporation is operating at about 92 per cent, and even as to a continuance of the present rates of operation the Steel Corporation has the better outlook.

There is more or less similarity in the predictions as to future of the iron and steel market—that there will be no very material improvement in demand before the second half or third quarter of the year.

PRICES

There are reports of price cutting on the part of independents, but the really important point in the market is that there is not enough business being offered to induce general price cutting if the willingness to cut prices were complete. The real test is not being furnished. A sale of blue annealed sheets at \$3 a ton under the regular market of 3.55c., base, is reported, but that was 1,000 tons to the Standard Oil Co., on a very attractive specification. Orders so attractive are not common even in an active market, hence it seems to be a case of the exception that tests the rule. If \$3 is the limit of concession in such cases, an ordinary order would hardly bring out any shading.

Again, it is reported that mills in the Chicago district are shading prices on certain commodities by various amounts up to \$4 a ton, but in this case again it is a matter of the "Pittsburgh basing," the nominal market at Chicago being the Pittsburgh price plus freight, which is \$7.60, so that the Chicago mill would still be getting several dollars a ton more than the Pittsburgh price, and in a weak market the Pittsburgh basing is not expected to stand.

Regular prices remain as follows: Bars, 2.35c.; shapes, 2.45c.; plates, 2.65c.; grooved steel skelp, 2.45c.; universal mill skelp, 3.55c.; sheared skelp, 2.65c.; standard steel pipe, 57½ per cent basing discount; plain wire, 3.25c.; wire nails, \$3.25; blue annealed sheets, 10-gage, 3.55c.; black sheets, 28 gage, 4.35c.; galvanized sheets, 28-gage, 5.70c.; tin plate, \$7 per base box, 100 lb.; hoops, 3.05c.; hot-rolled strip, 3.30c.; cold-rolled strip, 6.25c. Standard railroad spikes are 3.65c.; cold-finished steel bars 3.60c., chain 7.25c. base, structural rivets 4c. and boiler rivets 4.10c. Rivets have come down somewhat in the past week, the other prices having been in force for several weeks.

PIG IRON

Bessemer and basic have been wholly inactive, and remain quotable at \$32 and \$30 respectively, valley furnaces, the levels to which they declined at the beginning of the year. Several sales of foundry iron in lots of about 500 tons each have established the quotable market at \$31.50 valley, a decline of \$1.50 in the week. Pig iron in the valley market has now declined nearly \$20 a ton since the high point of last August, and in proportion to the drop that has occurred the market has relatively little room for further decline. The greatly advanced freight rates represent several dollars per ton of pig iron by which pre-war prices could not be attained, and there are high wages in the Connellsville coke region, probably impossible of much reduction while the present high mining scale obtains in the union bituminous coal regions. The independents in the Lake Superior ore region are reducing wages by 15 per cent, but that does not indicate any close approach to pre-war prices for ore. The extreme estimate is that pig iron may get down to \$25 within the next six or nine months.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.		\$0.55 - \$0.60
Acetone	lb.	\$0.13 - \$0.13	.13 - .14
Acid, acetic, 28 per cent	100 lbs.	3.00 - 3.25	3.50 - 3.75
Acetic, 56 per cent	100 lbs.	6.00 - 6.25	6.50 - 6.75
Acetic, glacial, 99½ per cent, carboys	100 lbs.	10.50 - 11.00	11.25 - 11.50
Boric, crystals	lb.	.14 - .15	.15 - .16
Boric, powder	lb.	.15 - .16	.17 - .18
Citric	lb.		.46 - .48
Hydrochloric	100 lb.	1.60 - 1.75	1.85 - 2.25
Hydrofluoric, 52 per cent	lb.	.15 - .16	.16 - .18
Lactic, 44 per cent tech.	lb.	.10 - .11	.11 - .12
Lactic, 22 per cent tech.	lb.	.04 - .05	.06 - .07
Molybdic, C. P.	lb.	4.00 - 4.50	4.50 - 5.00
Muriatic, 20 deg. (see hydrochloric)	lb.		.38 - .08
Nitric, 40 deg.	lb.	.07 - .07	.09 - .10
Nitric, 42 deg.	lb.	.08 - .09	.19 - .20
Oxalic, crystals	lb.	.18 - .18	.18 - .19
Phosphoric, ortho, 50 per cent solution	lb.	.18 - .18	.35 - .40
Picric	lb.	.30 - .32	2.30 - 2.40
Pyrogallol, resublimed	lb.		14.00 - 15.00
Sulphuric, 60 deg., tank cars	ton		22.50 - 23.00
Sulphuric, 60 deg., drums	ton	18.00 - 19.00	
Sulphuric, 66 deg., tank cars	ton	21.00 - 22.00	
Sulphuric, 66 deg., drums	ton		
Sulphuric, 66 deg., carboys	ton		
Sulphuric, fuming, 20 per cent (oleum)	ton	23.00 - 24.00	
Sulphuric, fuming, 20 per cent (oleum)	ton	25.00 - 26.00	
Sulphuric, fuming, 20 per cent (oleum)	ton		26.50 - 27.00
Sulphuric, fuming, 20 per cent (oleum)	ton		
Sulphuric, fuming, 20 per cent (oleum)	ton	32.00 - 35.00	
Tannic, U. S. P.	lb.		1.15 - 1.25
Tartaric (tech.)	lb.	.45 - .47	.46 - .50
Tartaric, crystals	lb.		.33 - .35
Tungstic, per lb. of WO	lb.		1.20 - 1.40
Alcohol, Ethyl	gal.		5.10 - 5.50
Alcohol, Methyl (see methanol)	gal.		.66 - .70
Alcohol, denatur ed, 188 proof	gal.		.71 - .75
Alcohol, denatur ed, 190 proof	gal.		.05 - .05
Alum, ammonia lump	lb.	.04 - .04	.05 - .05
Alum, potash lump	lb.	.05 - .06	.06 - .07
Alum, chrome lump	lb.	.13 - .13	.14 - .14
Aluminum sulphate, commercial	lb.	.02 - .02	.03 - .03
Aluminum sulphate, iron free	lb.	.03 - .03	.04 - .04
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.06 - .07	.07 - .08
Ammonia, anhydrous, cyl. (100-150 lb.)	lb.	.30 - .32	.33 - .35
Ammonium carbonate, powder	lb.	.12 - .12	.13 - .13
Ammonium chloride, granular (white)	lb.	.08 - .09	.09 - .09
Ammonium chloride, granular (gray)	lb.	.08 - .08	.09 - .09
Ammonium nitrate	lb.	.09 - .09	.10 - .10
Ammonium sulphate	lb.	.03 - .03	.04 - .04
Amylacetate	gal.		4.25 - 4.50
Am-lacetate tech.	gal.		3.50 - 3.75
Arsenic oxide, (white arsenic)	lb.	.10 - .11	.11 - .11
Arsenic, sulphide, powdered (red arsenic)	lb.	.15 - .15	.15 - .16
Barium chloride	ton	75.00 - 80.00	85.00 - 90.00
Barium dioxide (peroxide)	lb.	.24 - .25	.26 - .27
Barium nitrate	lb.	.10 - .10	.10 - .11
Barium sulphate (precip.) (blanc fixe)	lb.	.04 - .05	.05 - .06
Bleaching powder (see calc. hypochlorite)	lb.		
Blue vitriol (see copper sulphate)	lb.		
Borax (see sodium borate)	lb.		
Brimstone (see sulphur, roll)	lb.		
Bromine	lb.	.50 - .52	.54 - .56
Calcium acetate	100 lbs.	2.00 - 2.05	
Calcium carbide	lb.	.04 - .04	.04 - .05
Calcium chloride, fused, lump	ton	27.00 - 29.00	30.00 - 32.00
Calcium chloride, granulated	lb.	.02 - .02	.02 - .03
Calcium hypochlorite (bleaching powder)	lb.	.02 - .02	.03 - .03
Calcium peroxide	lb.		1.25 - 1.30
Calcium phosphate, monobasic	lb.		.16 - .18
Calcium sulphate, pure	lb.		.05 - .06
Camphor	lb.		.85 - .90
Carbon bisulphide	lb.	.08 - .08	.09 - .09
Carbon tetrachloride, drums	lb.	.11 - .11	.11 - .12
Carbonyl chloride (phosgene)	lb.		.60 - .75
Caustic potash (see potassium hydroxide)	lb.		
Caustic soda (see sodium hydroxide)	lb.		
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.09 - .09	.10 - .10
Chloroform	lb.		.43 - .50
Cobalt oxide	lb.		3.70 - 3.80
Copper as (see iron sulphate)	lb.		
Copper carbonate, green precipitate	lb.	.22 - .22	.24 - .25
Copper cyanide	lb.		.40 - .50
Copper sulphate, crystals	lb.	.06 - .06	.06 - .07
Cream of tartar (see potassium bitartrate)	lb.		
Epsom salt (see magnesium sulphate)	lb.		
Ethyl Acetate Com. 85%	gal.		1.05 - 1.10
Ethyl Acetate pure (acetic ether 98% to 100%)	gal.		
Formaldehyde, 40 per cent	lb.	.18 - .18	.19 - .20
Fusel oil, ref.	gal.		3.50 - 3.60
Fusel oil, crude	gal.		2.75 - 3.00
Glauber's salt (see sodium sulphate)	lb.		.20 - .21
Glycerine, C. P. drums extra	lb.		3.85 - 4.00
Iodine, resublimed	lb.		.10 - .20
Iron oxide, red	lb.		2.25 - 2.50
Iron sulphate (copperas)	100 lb.	1.75 - 2.00	
Lead acetate, normal	lb.		.14 - .16
Lead arsenate (paste)	lb.	.13 - .14	.14 - .15
Lead nitrate, crystals	lb.		.90 - 1.00
Litharge	lb.	.09 - .09	.09 - .10
Lithium carbonate	lb.		1.50 -
Magnesium carbonate, technical	lb.	.10 - .11	.11 - .12
Magnesium sulphate, U. S. P.	100 lb.	2.50 - 3.00	
Magnesium sulphate, commercial	100 lb.		1.50 - 1.75
Methanol 95%	gal.		1.30 - 1.40
Methanol, pure	gal.		1.50 - 1.70
Nickel salt, double	lb.		.12 - .12
Nickel salt, single	lb.		.13 - .13
Phosgene (see carbonyl chloride)	lb.		.47 - .50
Phosphorus, red	lb.	.45 - .46	.35 - .37
Phosphorus, yellow	lb.		.35 - .37
Potassium bichromate	lb.	.15 - .16	.16 - .16

	Carlots	Less Carlots
Potassium bitartrate (cream of tartar)..... lb.	\$ 33.00	\$ 35.00
Potassium bromide, granular..... lb.	25.00	40.00
Potassium carbonate, U. S. P..... lb.	35.00	40.00
Potassium carbonate, crude..... lb.	11.00	11.00
Potassium chlorate, crystals..... lb.	10.00	11.00
Potassium cyanide..... lb.	14.00	14.00
Potassium hydroxide (caustic potash)..... lb.	14.00	14.00
Potassium muriate..... ton	75.00	80.00
Potassium iodide..... lb.	11.00	12.00
Potassium nitrate..... lb.	11.00	12.00
Potassium permanganate..... lb.	55.00	60.00
Potassium prussiate, red..... lb.	50.00	52.00
Potassium prussiate, yellow..... lb.	31.00	31.00
Potassium sulphate (powdered)..... ton	\$225.00	\$230.00
Rochelle salts (see sodium potas. tartrate)		
Sal ammoniac (see ammonium chloride)		
Salt soda (see sodium carbonate)		
Salt cake..... ton	33.00	35.00
Silver cyanide..... oz.	1.25	1.45
Silver nitrate..... oz.	4.44	4.50
Soda ash, light..... 100 lb.	2.15	2.20
Soda ash, dense..... 100 lb.	2.60	2.75
Sodium acetate..... lb.	0.51	0.51
Sodium bicarbonate..... 100 lb.	2.40	2.50
Sodium bichromate..... lb.	0.81	0.91
Sodium bisulphate (nitre cake)..... ton	7.00	7.50
Sodium bisulphate powdered, U. S. P..... lb.	0.06	0.07
Sodium borate (borax)..... lb.	0.07	0.07
Sodium carbonate (sal soda)..... 100 lb.	2.00	2.25
Sodium chloride..... lb.	10.00	10.00
Sodium cyanide, 96-98 per cent..... lb.	21.00	23.00
Sodium fluoride..... lb.	17.00	17.00
Sodium hydroxide (caustic soda)..... 100 lb.	3.90	4.60
Sodium hyposulphite..... lb.	2.85	3.00
Sodium nitrate..... lb.	0.06	0.06
Sodium peroxide, powdered..... lb.	30.00	31.00
Sodium phosphate, dibasic..... lb.	0.31	0.41
Sodium potassium tartrate (Rochelle salts)..... lb.	17.00	17.00
Sodium prussiate, yellow..... lb.	0.11	0.11
Sodium silicate, solution (40 deg.)..... lb.	0.03	0.03
Sodium silicate, solution (60 deg.)..... lb.	0.03	0.03
Sodium sulphate, crystals (Glauber's salt) 100 lbs.	1.75	2.00
Sodium sulphide, crystal, 60-62 per cent (conc.) lb.	0.05	0.05
Sodium sulphite, crystals..... lb.	0.04	0.04
Strontium nitrate, powdered..... lb.	20.00	20.00
Sulphur, red, refined..... lb.	0.08	0.09
Sulphur, crude..... ton	16.00	20.00
Sulphur dioxide, liquid, cylinders..... lb.	0.09	0.10
Sulphur (sublimed), flour..... 100 lb.	3.70	4.35
Sulphur, roll (brimstone)..... 100 lb.	3.40	3.90
Tin bichloride, 50 per cent..... lb.	18.00	19.00
Tin oxide..... lb.	48.00	50.00
Zinc carbonate, precipitate..... lb.	16.00	18.00
Zinc chloride, gran..... lb.	11.00	12.00
Zinc cyanide..... lb.	45.00	49.00
Zinc dust..... lb.	12.00	13.00
Zinc oxide, XX..... lb.	10.00	10.00
Zinc sulphate..... lb.	0.31	0.31

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha-naphthol, crude..... lb.	\$1.10	\$1.15
Alpha-naphthol, refined..... lb.	1.45	1.50
Alpha-naphthylamine..... lb.	40.00	44.00
Aniline oil, drums extra..... lb.	26.00	28.00
Aniline salts..... lb.	27.00	30.00
Anthracene, 80% in drums (100 lb.)..... lb.	85.00	1.00
Benzaldehyde (f.f.c.)..... lb.	2.00	2.10
Benzidine, base..... lb.	1.00	1.10
Benzidine sulphate..... lb.	85.00	90.00
Benzoic acid, U. S. P..... lb.	70.00	75.00
Benzoate of soda, U. S. P..... lb.	75.00	85.00
Benzene, pure, water-white, in drums (100 gal.)..... gal.	30.00	35.00
Benzene, 90% in drums (100 gal.)..... gal.	28.00	32.00
Benzyl chloride, 95-97% refined..... lb.	30.00	35.00
Benzyl chloride, tech..... lb.	25.00	30.00
Beta-naphthol benzoate..... lb.	3.50	4.00
Beta-naphthol, sublimed..... lb.	75.00	80.00
Beta-naphthol, tech (nominal)..... lb.	35.00	40.00
Beta-naphthylamine, sublimed..... lb.	2.25	2.40
Cresol, U. S. P., in drums (100 lb.)..... lb.	16.00	18.00
Ortho-cresol, in drums (100 lb.)..... lb.	23.00	25.00
Cresylic acid, 97-99%, straw color, in drums..... gal.	95.00	1.00
Cresylic acid, 75-97%, dark, in drums..... gal.	90.00	95.00
Cresylic acid, 50% first quality, drums..... gal.	65.00	75.00
Dichlorobenzene..... lb.	0.06	0.09
Diethylaniline..... lb.	1.25	1.30
Dimethylaniline..... lb.	0.65	0.75
Dinitrobenzene..... lb.	30.00	32.00
Dinitrochlorobenzene..... lb.	25.00	30.00
Dinitronaphthalene..... lb.	35.00	40.00
Dinitrophenol..... lb.	40.00	45.00
Dinitrotoluene..... lb.	27.00	30.00
Dip oil, 25% tar acids, car lots, in drums..... gal.	38.00	40.00
Diphenylamine..... lb.	65.00	70.00
H-acid..... lb.	1.40	1.55
Meta-phenylenediamine..... lb.	1.25	1.30
Monochlorobenzene..... lb.	14.00	16.00
Monoethylaniline..... lb.	1.75	2.25
Naphthalene crushed, in bbls. (250 lb.)..... lb.	0.08	0.08
Naphthalene, flake..... lb.	0.08	0.08
Naphthalene, balls..... lb.	0.09	0.09
Naphthalenic acid, crude..... lb.	70.00	75.00
Nitrobenzene..... lb.	12.00	15.00
Nitronaphthalene..... lb.	40.00	50.00
Nitro-toluene..... lb.	18.00	25.00
Ortho-amidophenol..... lb.	3.20	3.75
Ortho-dichlorobenzene..... lb.	15.00	20.00
Ortho-nitrophenol..... lb.	75.00	80.00
Ortho-nitro-toluene..... lb.	20.00	28.00
Ortho-toluidine..... lb.	25.00	30.00
Para-amidophenol, base..... lb.	1.90	2.00
Para-amidophenol, HCl..... lb.	2.20	2.25

Para-dichlorobenzene..... lb.	15.00	25.00
Paranitroaniline..... lb.	93.00	1.00
Para-nitrotoluene..... lb.	1.05	1.15
Para-phenylenediamine..... lb.	2.20	2.35
Para-toluidine..... lb.	1.50	1.60
Phthalic anhydride..... lb.	55.00	60.00
Phenol, U. S. P., drums (dest.), (240 lb.)..... lb.	10.00	12.00
Pyridine..... gal.	2.00	3.50
Resorcinol, technical..... lb.	2.25	2.50
Resorcinol, pure..... lb.	3.60	3.80
Salicylic acid, tech., in bbls. (110 lb.)..... lb.	25.00	28.00
Salicylic acid, U. S. P..... lb.	29.00	35.00
Salol..... lb.	85.00	95.00
Solvent naphtha, water-white, in drums, 100 gal..... gal.	28.00	32.00
Solvent naphtha, crude, heavy, in drums, 100 gal..... gal.	16.00	18.00
Sulphanilic acid, crude..... lb.	30.00	35.00
Tolidine..... lb.	1.45	1.60
Toluidine, mixed..... lb.	40.00	45.00
Toluene, in tank cars..... gal.	30.00	32.00
Toluene, in drums..... gal.	33.00	35.00
Xylidines, drums, 100 gal..... lb.	45.00	50.00
Xylene, pure, in drums..... gal.	42.00	45.00
Xylene, pure, in tank cars..... gal.	45.00	50.00
Xylene, commercial, in drums, 100 gal..... gal.	33.00	35.00
Xylene, commercial, in tank cars..... gal.	30.00	35.00

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark..... lb.	\$0.24	\$0.26
Beeswax, refined, light..... lb.	27.00	28.00
Beeswax, white pure..... lb.	35.00	40.00
Carnauba, No. 1..... lb.	85.00	90.00
Carnauba, No. 2, North Country..... lb.	35.00	40.00
Carnauba, No. 3, North Country..... lb.	19.00	20.00
Japan..... lb.	19.00	20.00
Montan, crude..... lb.	07.00	08.00
Paraffine waxes, crude match wax (white) 105-110 m.p..... lb.	05.00	05.00
Paraffine waxes, crude, scale 124-126 m.p..... lb.	04.00	05.00
Paraffine waxes, refined, 118-120 m.p..... lb.	06.00	06.00
Paraffine waxes, refined, 125 m.p..... lb.	07.00	07.00
Paraffine waxes, refined, 128-130 m.p..... lb.	07.00	08.00
Paraffine waxes, refined, 133-135 m.p..... lb.	09.00	09.00
Paraffine waxes, refined, 135-137 m.p..... lb.	10.00	11.00
Stearic acid, single pressed..... lb.	13.00	13.00
Stearic acid, double pressed..... lb.	13.00	14.00
Stearic acid, triple pressed..... lb.	14.00	14.00

Flotation Oils

All prices are f.o.b. New York unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp.gr., 0.930-0.940..... gal.	\$1.70
Pine oil, pure, dist. dist..... gal.	1.60
Pine tar oil, ref., sp.gr. 1.025-1.035..... gal.	48.00
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla..... gal.	35.00
Pine tar oil, double ref., sp.gr. 0.965-0.990..... gal.	75.00
Pine tar, ref., thin, sp.gr., 1.080-1.060..... gal.	36.00
Turpentine, crude, sp. gr., 0.900-0.970..... gal.	1.20
Hardwood oil, f.o.b. Mich., sp.gr., 0.960-0.990..... gal.	37.00
Pinewood creosote, ref..... gal.	55.00

Naval Stores

The following prices are f.o.b. New York for carload lots.

Rosin B-D, bbl..... 280 lb.	\$8.75
Rosin E-I..... 280 lb.	8.75
Rosin K-N..... 280 lb.	8.75
Rosin W. G.-W. W..... 280 lb.	9.00
Wood rosin, bbl..... 280 lb.	9.00
Spirits of turpentine..... gal.	76.00
Wood turpentine, steam dist..... gal.	72.00
Wood turpentine, dest. dist..... gal.	71.00
Pine tar pitch, bbl..... 200 lb.	8.50
Tar, kiln burned, bbl. (50 lb.)..... bbl.	15.00
Retort tar, bbl..... 500 lb.	15.00
Rosin oil, first run..... gal.	52.00
Rosin oil, second run..... gal.	54.00
Rosin oil, third run..... gal.	62.00

Solvents

73-76 deg., steel bbls. (85 lb.)..... gal.	\$0.41
70-72 deg., steel bbls. (85 lb.)..... gal.	39.00
68-70 deg., steel bbls. (85 lb.)..... gal.	38.00
V. M. and P. naphtha, steel bbls. (85 lb.)..... gal.	30.00

Crude Rubber

Para-Upriver fine..... lb.	\$0.18	\$0.19
Upriver coarse..... lb.	14.00	14.00
Upriver caucho ball..... lb.	14.00	14.00
Plantation—First latex crepe..... lb.	21.00	21.00
Ribbed smoked sheets..... lb.	20.00	20.00
Brown crepe, thin, clean..... lb.	18.00	18.00
Amber crepe No. 1..... lb.	20.00	20.00

Oils

VEGETABLE

The following prices are f.o.b. New York for carload lots.

Castor oil, No. 3, in bbls..... lb.	\$0.09	\$0.10
Castor oil, AA, in bbls..... lb.	11.00	11.00
China wood oil, in bbls. (f.o.b. Pac. coast)..... lb.	08.00	09.00
Cocoonut oil, Ceylon grade, in bbls..... lb.	12.00	13.00
Cocoonut oil, Cochinchina grade, in bbls..... lb.	12.00	13.00
Corn oil, crude, in bbls..... lb.	08.00	09.00
Cottonseed oil, crude (f. o. b. mill)..... lb.	06.00	07.00
Cottonseed oil, summer yellow..... lb.	09.00	09.00
Cottonseed oil, winter yellow..... lb.	09.00	09.00
Linseed oil, raw, car lots (domestic)..... gal.	76.00	77.00
Linseed oil, raw, tank cars (domestic)..... gal.	69.00	70.00
Linseed oil, boiled, car lots (domestic)..... gal.	78.00	79.00

Olive oil, commercial.....	gal.	\$2 50	—	\$2 60
Palm, Lagos.....	lb.	.07	—	.08
Palm, Niger.....	lb.	.07	—	.07
Peanut oil, crude, tank cars (f.o.b. mill).....	lb.	.07	—	.07
Peanut oil, refined, in bbls.....	lb.	.13	—	.13
Rapeseed oil, refined in bbls.....	gal.	1 10	—	1 15
Rapeseed oil, blown, in bbls.....	gal.	1 20	—	1 25
Soya bean oil (Manchurian), in bbls. N. Y.....	lb.	.08	—	.09
Soya bean oil, tank cars, f.o.b., Pacific coast.....	lb.	.05	—	.06

FISH

Light pressed menhaden.....	gal.	\$0 53	—	\$0 55
Yellow bleached menhaden.....	gal.	.55	—	.58
White bleached menhaden.....	gal.	.57	—	.60
Blown menhaden.....	gal.	1 00	—	.....

Miscellaneous Materials

All f.o.b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.....	net ton	\$24 00	—	30 00
Barytes, ground, off color, f.o.b. Kings Creek.....	net ton	22 00	—	26 00
Barytes, crude, 88% @ 94% ba., Kings Creek.....	net ton	10 00	—	12 00
Barytes, floated, f.o.b. St. Louis.....	net ton	26 50	—	28 00
Barytes, crude, first grade, Missouri.....	net ton	10 00	—	.....
Blane fixe, dry.....	lb.	.05	—	.05
Blane fixe, pulp.....	net ton	60 00	—	65 00
Ca-sin.....	lb.	.14	—	.18
Chalk, domestic, extra light.....	lb.	.05	—	.05
Chalk, domestic, light.....	lb.	.04	—	.05
Chalk, domestic, heavy.....	lb.	.04	—	.05
Chalk, English, extra light.....	lb.	.05	—	.07
Chalk, English, light.....	lb.	.05	—	.06
Chalk, English, dense.....	lb.	.04	—	.05
China clay (kaolin) crude, f.o.b. mines, Georgia.....	net ton	8 00	—	10 00
China clay (kaolin) washed, f.o.b. Georgia.....	net ton	12 00	—	15 00
China clay (kaolin) powdered, f.o.b. Georgia.....	net ton	18 00	—	22 00
China clay (kaolin) crude f.o.b. Virginia points.....	net ton	8 00	—	12 00
China clay (kaolin) ground, f.o.b. Virginia points.....	net ton	15 00	—	40 00
China clay (kaolin), imported, lump.....	net ton	25 00	—	35 00
China clay (kaolin), imported, powdered.....	net ton	30 00	—	35 00
Feldspar, crude, f.o.b. Maryland and North Carolina points.....	gross ton	8 00	—	14 00
Feldspar, crude, f.o.b. Maine.....	net ton	7 50	—	10 00
Feldspar, ground, f.o.b. Maine.....	net ton	21 00	—	23 00
Feldspar, ground, f.o.b. North Carolina.....	net ton	17 00	—	21 00
Feldspar, ground, f.o.b. N. Y. State.....	net ton	17 00	—	21 00
Feldspar, ground, f.o.b. Baltimore.....	net ton	27 00	—	30 00
Fullers earth, f.o.b. New York.....	net ton	16 00	—	17 00
Fullers earth, granular, f.o.b. Fla.....	net ton	25 00	—	.....
Fullers earth, powdered, f.o.b. Fla.....	net ton	18 00	—	.....
Fullers earth, imported, powdered.....	net ton	35 00	—	40 00
Graphite, crucible, 90% carbon, Ashland, Ala.....	lb.	.07	—	.09
Graphite, crucible, 85% carbon, Ashland, Ala.....	lb.	.11	—	.40
Graphite, higher lubricating grades.....	lb.	.04	—	.50
Pumice stone, imported, lump.....	lb.	.06	—	.....
Pumice stone, domestic lump.....	lb.	.04	—	.07
Pumice stone, ground.....	lb.	.04	—	.07
Quartz (acid tower) first to head, f.o.b. Baltimore.....	net ton	.....	—	10 00
Quartz (acid tower) 1 1/2 @ 2 in., f.o.b. Baltimore.....	net ton	.....	—	14 00
Quartz (acid tower) rice, f.o.b. Baltimore.....	net ton	.....	—	17 00
Quartz, lump, f.o.b. North Carolina.....	net ton	5 00	—	7 50
Shellac, orange fine.....	lb.	.80	—	.85
Shellac, orange superfine.....	lb.	.95	—	1 00
Shellac, A. C. garret.....	lb.	.70	—	.75
Shellac, T. N.....	lb.	.68	—	.70
Soapstone.....	ton	15 00	—	25 00
Sodium chloride.....	long ton	.....	—	17 50
Talc, paper-making grades, f.o.b. Vermont.....	ton	12 00	—	22 00
Talc, roofing grades, f.o.b. Vermont.....	ton	9 50	—	15 00
Talc, rubber grades, f.o.b. Vermont.....	ton	12 00	—	18 00
Talc, powdered, Southern, f.o.b. cars.....	ton	12 00	—	15 00
Talc, imported.....	ton	40 00	—	50 00
Talc, California talcum powder grade.....	ton	20 00	—	45 00

Refractories

Bauxite brick, 56% Al, f.o.b. Pittsburgh.....	1,000	160	—	.....
Chrome brick, f.o.b. Eastern shipping points.....	net ton	100—	110	.....
Chrome cement, 40-45% Cr ₂ O ₃ , sacks, in car lots, f.o.b. Eastern shipping points.....	net ton	60—	65	.....
Fireclay brick, 1st quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works.....	1,000	55—	60	.....
Fireclay brick, 2nd quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works.....	1,000	45—	50	.....
Magnesite brick, 9-in. straight.....	net ton	110	—	.....
Magnesite brick, 9-in. arches, wedges and keys.....	net ton	121	—	.....
Magnesite brick, soaps and splits.....	net ton	134	—	.....
Silica brick, 9-in. sizes, f.o.b. Chicago district.....	1,000	65—	70	.....
Silica brick, 9-in. sizes, f.o.b. Birmingham district.....	1,000	56—	61	.....
Silica brick, 9-in. sizes, f.o.b. Mt. Union, Pa.....	1,000	55—	60	.....

Ferro-Alloys

All f.o.b. Works

Ferrocobalt-titanium, 15-18% Co, f.o.b. Niagara Falls, N. Y.....	net ton	\$200 00	—	\$225 00
Ferrochrome per lb. of Cr. contained, 6-8% carbon, carlots.....	lb.	.16	—	.17
Ferrochrome, per lb. of Cr. contained, 4-6% carbon, carlots.....	lb.	.17	—	.18
Ferromanganese, 76-80% Mn, domestic.....	gross ton	105 00	—	110 00
Ferromanganese, 76-80% Mn, English.....	gross ton	110 00	—	115 00
Spiegelisen, 18-22% Mn.....	gross ton	55 00	—	60 00
Ferromolybdenum, 50-60% Mo, per lb. of Mo.....	lb.	2 00	—	2 50
Ferrosilicon, 10-15% Si.....	gross ton	55 00	—	60 00
Ferrosilicon, 50% Si.....	gross ton	78 00	—	80 00
Ferrosilicon, 75% Si.....	gross ton	.....	—	150 00
Ferrotungsten, 70-80% per lb. of contained W.....	lb.	.55	—	.60
Ferrourenium, 35-50% per lb. of U, of contained U.....	lb.	7 00	—	.....
Ferrovandium, 30-40% per lb. of contained V.....	lb.	5 75	—	6 75

Ores and Semi-finished Products

All f.o.b. New York, Unless Otherwise Stated

Bauxite, 52% Al content, less than 2% Fe ₂ O ₃ , up to 20% silica, not more than H 4% moisture.....	gross ton	\$10 00	—	\$11 00
Chrome ore, Calif. concentrates, 50% min. Cr ₂ O ₃	unit	.60	—	.65
Chrome ore, 50% Cr ₂ O ₃ , f.o.b. Atlantic seaboard.....	unit	.55	—	.60
Coke, foundry, f.o.b. ovens.....	net ton	.....	—	7 00
Coke, furnace, f.o.b. ovens.....	net ton	.....	—	6 00
Coke, petroleum, refinery, Atlantic seaboard.....	net ton	21 00	—	22 00
Fluorspar, lump, f.o.b. Tonuco, New Mexico.....	net ton	15 00	—	.....
Fluorspar, standard, domestic washed gravel Kentucky and Illinois mines.....	net ton	22 50	—	25 00
Ilmenite, 52% TiO ₂ , per lb. ore.....	lb.	.01	—	.01
Manganese ore, 50% Mn, c.i.f. Atlantic seaport.....	unit	.38	—	.40
Manganese ore, chemical (MnO ₂).....	gross ton	60 00	—	65 00
Molybdenite, 85% MoS ₂ , per lb. of MoS ₂ , N. Y.....	lb.	.55	—	.65
Monazite, per unit of ThO ₂ , c.i.f. Atlantic seaport.....	unit	35 00	—	.....
Pyrites, Spanish, fines, c.i.f. Atlantic seaport.....	unit	.12	—	.....
Pyrites, furnace size, c.i.f. Atlantic seaport.....	unit	.17	—	.....
Pyrites, domestic, fines, f.o.b. mines, Ga.....	unit	.12	—	.14
Rutile, 95% TiO ₂ , per lb. ore.....	lb.	.15	—	.....
Tungsten, scheelite, 60% WO ₃ and over, per unit of WO ₃ (nominal).....	unit	3 00	—	3 50
Tungsten, wolframite, 60% WO ₃ and over, per unit of WO ₃ , N. Y. C.....	unit	3 00	—	3 50
Uranium ore (carnotite) per lb. of U ₃ O ₈	lb.	2 75	—	3 00
Uranium oxide, 96% per lb. contained U ₃ O ₈	lb.	2 75	—	3 00
Vanadium pentoxide, 99%.....	lb.	12 00	—	14 00
Vanadium ore, per lb. of V ₂ O ₅ contained.....	lb.	1 50	—	.....
Zircon, washed, iron free.....	lb.	.05	—	.....

Non-Ferrous Metals

New York Markets

	Cents per Lb.
Copper, electrolytic.....	15 00
Aluminum, 98 to 99 per cent.....	27 50
Antimony, wholesale lots, Chinese and Japanese.....	5 25 @ 5 37 1/2
Nickel, ordinary (ingot).....	43 00
Nickel, electrolytic.....	45 00
Monel metal, spot and blacks.....	35
Monel metal ingots.....	38
Monel metal, sheet bars.....	40
Tin, 5-ton lots.....	34 02 1/2
Lead, New York, spot.....	5 37 1/2
Lead, E. St. Louis, spot.....	6 25
Zinc, spot, New York.....	7 00
Zinc, spot, E. St. Louis.....	6 75

OTHER METALS

Silver (commercial).....	oz.	\$0 66 1/2
Cadmium.....	lb.	1 40 @ 1 50
Bismuth (500 lb. lots).....	lb.	2 40
Cobalt.....	lb.	6 00
Magnesium (f.o.b. Philadelphia).....	lb.	1 35
Platinum.....	oz.	75 00
Iridium.....	oz.	350 00 @ 400 00
Palladium.....	oz.	75 00
Mercury.....	75 lb.	50 00

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled.....	21 50
Copper bottoms.....	33 00
Copper rods.....	28 00
High brass wire and sheets.....	19 25
High brass rods.....	17 25
Low brass wire and sheets.....	29 50
Low brass rods.....	18 50
Brazed brass tubing.....	35 25
Brazed bronze tubing.....	40 50
Seamless copper tubing.....	25 00
Seamless high brass tubing.....	24 00

OLD METALS—The following are the dealers' purchasing prices in cents per pound:

	New York				Cleveland	Chicago
	Current	One Month Ago	One Year Ago	Current	Current	Current
Copper, heavy and crucible.....	11 50	18 50	10 00	10 50		
Copper, heavy and wire.....	11 00	16 50	9 50	10 00		
Copper, light and bottoms.....	9 00	14 50	9 00	9 00		
Lead, heavy.....	4 00	7 25	4 00	4 00		
Lead, tea.....	3 00	5 25	3 00	3 50		
Brass, heavy.....	7 00	9 50	7 00	10 00		
Brass, light.....	5 50	8 00	5 00	5 50		
No. 1 yellow brass turnings.....	6 00	9 50	5 50	5 50		
Zinc.....	4 00	5 00	3 00	4 25		

Structural Material

The following base prices per 100 lb. are for structural shapes 3 in. by 1/2 in. and larger, and plates 1/2 in. and heavier, from jobbers' warehouses in the cities named:

	New York			Cleveland		Chicago	
	Current	One Month Ago	One Year Ago	Current	One Year Ago	Current	One Year Ago
Structural shapes.....	\$3 58	\$3 80	\$3 47	\$3 58	\$3 37	\$3 58	\$3 47
Soft steel bars.....	3 45	3 70	3 37	3 34	3 27	3 48	3 52
Soft steel bar shapes.....	3 45	3 70	3 37	3 48	3 27	3 48	3 52
Soft steel bands.....	4 18	4 65	4 07	6 25	.....	.....	.....
Plates, 1/2 to 1 in. thick.....	3 78	4 00	3 67	3 78	3 57	3 78	3 67

Industrial

Financial, Construction and Manufacturers' News

Colorado

GARFIELD—Harrison Petroleum Co., Grand Valley, is having plans prepared for the construction of 1,000 ton shale oil refinery for manufacture of gasoline, lubricating oils and paraffine. Estimated cost \$500,000. H. C. Wolf, Oklahoma City, engr.

Idaho

KELLOGG—Bunker Hill & Sullivan M. & C. Co. plans to build electrolytic zinc refinery, with 25 ton metallic zinc capacity per day. Above project will be conjunction with lead concentrator and smelter of company, here. Estimated cost \$1,000,000. F. M. Smith, dir.

Iowa

BELLE PLAINE—The Bd. of Educ. is having plans prepared for the construction of a 2 story, 83 x 130 ft. high school. A chemical laboratory will be installed in same. Estimated cost, \$100,000. C. R. Ahrens, Secy. C. A. Dieman & Co., 408 Granby Bldg., Cedar Rapids, archt.

CORYDON—The Bd. of Educ. will receive bids until Feb. 10 for the construction of a 3 story, 67 x 121 ft. high school. A chemical laboratory will be installed in same. Estimated cost, \$160,000. D. T. Sellenberger, Pres. W. Gordon, 319 Hubbell Bldg., Des Moines, Archt. noted Dec. 1.

Kansas

PARSONS—City is having plans prepared for rehabilitation of waterworks plant including installation of filter equipment and machinery for 6,000,000 gal. capacity. Estimated cost \$350,000,000. Burns & McDonnell Engr. Co., Interstate Bldg., Kansas City, Mo., assigning and consulting engs.

Maine

RICHMOND—THE City Waterworks plans to construct a filtration plant. Cost between \$18,000 and \$20,000.

Michigan

BENTON HARBOR—City is having plans prepared for installation of filtration plant. Estimated cost \$100,000. Greeley, Pearce & Hansen, 39 West Adams St., Chicago, engs.

CADILLAC—St. Mary's Hospital will receive bids in the early spring for construction of 3 story hospital. A chemical laboratory will be installed in same. Estimated cost \$250,000. E. Brilemaier Sons, 432 Bway, Milwaukee, archts.

FENTON—The Bd. of Educ., c/o M. B. Smith is having plans prepared for the construction of a 2 story high school. A chemical laboratory will be installed in same. Estimated cost, \$200,000. Van Leyen, Schilling, Keough & Reynolds, 3440 Cass Ave., Detroit, archt.

Minnesota

ALBERT LEA—The Central Fdry. Co., Marshalltown, Ia., plans to construct a 1 story, 100 x 200 ft. factory here. Estimated cost, \$50,000.

EVELETH—City has received bids for construction of a filtration plant, from Lawrence McCann Co., Eveleth, \$178,350; Roberts Mfg. Co., Eveleth, \$179,870; Phelps-Drake Co., 631 Metropolitan Life Bldg., Minneapolis, \$184,730. Noted Sept. 17.

Montana

MILES CITY—Custer Co. Free High School has awarded the contract for construction of 3 story, 152 x 210 ft. high school, to Lease & Lieglund, Great Falls. Estimated cost \$195,000. A chemical laboratory will be installed in same. Noted Jan. 12.

Nebraska

NELSON—Bd. of Educ. has plans prepared for the construction of a 2 story high school. A chemical laboratory will be installed in same. Estimated cost, \$90,000. H. D. Pampel, 402 Finance Bldg., Kansas City, Mo., archt.

New York

BROOKLYN—W. Scandon Paper Box Co. will build a 2 story, 40 x 100 ft. factory at 150 Skillman St. Estimated cost, \$35,000.

CARTHAGE—The Northern Development Syndicate plans to construct a commercial size ore reduction plant and electric smelting furnace.

OLEAN—England, Walton & Co., Inc., plans to rebuild its six tannery buildings which were recently destroyed by fire. Estimated cost, \$200,000.

North Dakota

JAMESTOWN—The city plans to improve waterworks system, including reservoir and water softener. Estimated cost, \$60,000. H. H. Hurning, city engr.

Ohio

CLEVELAND—The Frank Dry Cleaning Co., 1361 East 55th St., has awarded the contract for the construction of a 2 story, 44 x 76 ft. factory on East 60th St. and Bonna Ave. Estimated cost, \$50,000. M. H. Merver, mgr.

WEST CARROLLTON—American Envelope Co. is having plans prepared for construction of 2 story, 60 x 110 ft. factory, on Main St. Estimated cost \$50,000. E. J. Mountstephen, 803 U. B. Bldg., Dayton, archts.

YOUNGSTOWN—The Bd. of Educ., 16 West Wood St., will soon award the contract for the construction of a 2 story, 250 x 250 ft. high school on Ohio St. A chemical laboratory will be installed in same. Estimated cost, \$1,000,000. C. F. Owley, 1301 Mahoning Bank Bldg., archt.

Oregon

PORTLAND—Portland Vegetable Oil Mills Co. plans to build manufacturing plant, to have 100 ton vegetable oil capacity. Estimated cost \$450,000. C. A. Painton, pres.

Pennsylvania

SUGAR NOTCH—City plans to construct a 2 story, 100 x 120 ft. high school. A chemical laboratory will be installed in same.

South Dakota

MISSION—The Bd. of Educ., c/o S. D. Hickey, Co. Supt. of Schools, plans to construct a 2 story consolidated school. A chemical laboratory will be installed in same. Estimated \$125,000. Architect not announced.

SIOUX FALLS—The Bd. of Educ. is having plans prepared for the construction of a 3 or 4 story high school. A chemical laboratory will be installed in same. Estimated cost, \$400,000. Perkins & McWayne, 324 Paulton block, archts. H. S. Hillehoe, supt. of schools.

Texas

EASTLAND—The city has awarded the contract for the construction of storm and sanitary sewers and a sewage disposal plant to include a septic tank, sprinkling filter and sludge bed. Estimated cost, \$185,000. Noted Dec. 8.

FORT WORTH—The Masonic Grand Lodge of Texas, Waco, has awarded the contract for the construction of a 2 story hospital. A chemical laboratory will be installed in same. Estimated cost, \$90,000.

FT. WORTH—The Peden Iron & Steel Co., Main and Daggett Sts., is having plans prepared for the construction of a steel roller mill and fabricating plant. Estimated cost, \$1,000,000. D. R. Luce, Ft. Worth, engr.

RANGER—Chestnut & Smith are having plans prepared for the construction of a casinghead gasoline plant. Estimated cost, \$500,000.

RANGER—The Humble Oil & Refining Co., Goggen Bldg., Houston, is having plans prepared for the construction of a topping plant in connection with its oil refinery. Estimated cost, \$500,000.

Washington

MILLWOOD—The Inland Empire Paper Co. has awarded the contract for the construction of a brick and concrete addition to its paper mill. Estimated cost, \$85,000.

SEATTLE—The Rothert Process Steel Co., 622 Othello St., plans to construct several buildings and install one or two 15-

ton electric steel furnaces and other equipment, for manufacture of ingots, bar steel and high grade steel products from raw materials. E. H. Rothert, pres.

West Virginia

ROUND BOTTOM—H. J. Booth, 1675 Beechwood St., Pittsburgh, Pa., has purchased a site and plans to build a glass plant.

Wyoming

CASPER—E. LeRoy, Sistersville, West Virginia, plans to build plant, here, for manufacture of glass.

Ontario

LONDON—I. O. D. E., c/o Watt & Blackwell, archts., Bank of Toronto Chambers, has awarded the contract for the construction of a 4 story, 110 x 200 ft. children's hospital on Ottaway Ave. A chemical laboratory will be installed in same. Estimated cost, \$200,000.

WINDSOR—The Municipal School Bds. of Windsor and Walkerville plans to construct a 3 story technical school. A chemical laboratory will be installed in same. Estimated cost, \$500,000.

British Columbia

PRINCE RUPERT—Prince Rupert Pulp & Paper Co., Vancouver, plans to erect plant, here, for the manufacture of pulp and paper, to be in conjunction with general lumbering business. Estimated cost \$4,000,000.

Quebec

MONTANE—The Hammermill Paper Co., Erie, Pa., will receive bids the latter part of January for building a pulp and paper mill, here. Estimated cost, \$1,000,000.

MONTREAL—W. R. Cuthbert & Co., 41 Duhe St., plans to build a 3 story brass finishing factory. Estimated cost, with equipment, \$85,000.

ST. ANGELE DE LAVAL—The Brown Pulp & Paper Co. is having plans prepared for the construction of a pulp and paper mill. Estimated cost, \$1,500,000.

Coming Meetings and Events

AMERICAN CERAMIC SOCIETY will hold its annual meeting Feb. 21 to 24 at Columbus, Ohio, with headquarters at the Deschler Hotel.

AMERICAN CHEMICAL SOCIETY will hold its sixty-first meeting at Rochester, N. Y., April 26 to 29.

AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting at Atlantic City April 21 to 23 inclusive. Headquarters will be at the Hotel Chalfonte.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its spring meeting Feb. 14 to 17 in New York City.

AMERICAN SOCIETY FOR TESTING MATERIALS will hold its 1921 annual meeting in the New Monterey Hotel, Asbury Park, N. J., during the week of June 20.

COMMON BRICK MANUFACTURERS' ASSOCIATION OF AMERICA will hold its annual meeting at the Hotel Pennsylvania, New York City, Jan. 31 to Feb. 4.

NATIONAL PETROLEUM CONGRESS will meet at the Hotel Baltimore, Kansas City, Mo., March 22 to 25.

NEW JERSEY CHEMICAL SOCIETY holds a meeting at Stettens Restaurant, 842 Broad St., Newark, N. J., the second Monday of every month.

THE SEVENTH EXPOSITION OF CHEMICAL INDUSTRIES will be held during the week of Sept. 12, in the Eighth Coast Artillery Armory, New York City.

The following chemical societies will meet at Rumford Hall, Chemists' Club, New York City, as follows: Feb. 11, American Electrochemical Society, joint meeting with Society of Chemical Industry, American Chemical Society and Société de Chimie Industrielle; March 11, American Chemical Society; March 25, Society of Chemical Industry; April 22, Society of Chemical Industry, joint meeting with American Electrochemical Society, Société de Chimie Industrielle and American Chemical Society; May 6, American Chemical Society, Nichols Medal award; May 13, Société de Chimie Industrielle, joint meeting with American Chemical Society, Society of Chemical Industry and American Electrochemical Society; May 20, Society of Chemical Industry; June 10, American Chemical Society.